AERO DIGEST
INCLUDING AVIATION ENGINEERING

FEBRUARY 1955
50 CENTS

CHARLES M JAMIESON
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AKRON 12 OHIO

IN THIS I

DESIGN FO ...RAND PRIZE WINNERS

CRUISE PERFORMANCE OF JET AIRCRAFT

DISENTANGLING TURBULENCE

New Honeywell E-10 Autopilot helps fly the F-100 Super Sabre

THE extremely high performance characteristics of North American's new F-100 Super Sabre—plus the precise missions it will be required to fly—demand an entirely new high performance flight control system.

Honeywell is proud that its new E-10 Autopilot was selected to help fly the autopilot equipped Super Sabres.

Here are some features of the E-10 which make it an outstanding flight control system:

Mission matching adaptability to a wide variety of command signals—fire control, blind landing, cruise control, radio navigation.

Extremely rapid response of hydraulic servos.

Fully coordinated three axes stabilization.

Constant mach control in dive, climb or cruise.

Complete air speed compensation providing uniform response at all air speeds.

Control stick steering.

All-attitude maneuverability.

Components that make up the E-10 can be combined into highly effective control systems for dive bombing, interception, level bombing or normal cruise control for any high performance aircraft.

The new E-10 Jet Autopilot is another new development from Honeywell. There'll be more, for automatic control is so important to aviation's progress. And *automatic control* is Honeywell's business.

MINNEAPOLIS
Honeywell
Aeronautical Controls

2600 Ridgway Road, Minneapolis 13, Minnesota

How the Holley Turbine Control helps jet pilots concentrate on FIGHTING, not flying

Nearly every foot of altitude, gained or lost, nearly every minute change in atmospheric conditions alters the amount of fuel flow needed by today's jet engine. Literally hundreds of mathematical problems must be solved every minute a jet is in the air. It would be impossible for any pilot to solve all these problems and still have time to concentrate on fighting. So the Holley Turbine Control was developed to solve them for him AUTOMATICALLY.

Holley's research department played an important role in the development of this mechanical wizard. But producing Holley Turbine Controls requires special skills, too. Working to tolerances of as little as plus or minus 25 millionths of an inch, the Holley manufacturing division turns out turbine controls for thousands of today's jet aircraft.

Holley's highly-trained research, engineering and manufacturing staff can support your program of producing better products for the aviation industry, either your design or ours.

Leader in the design, development, and manufacture of aviation fuel metering devices.

HOLLEY Carburetor Co.

VAN DYKE, MICHIGAN

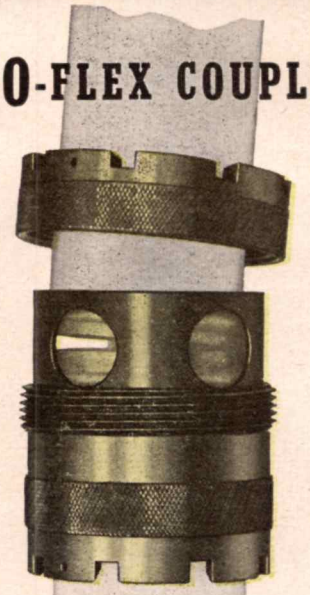
A-19

Are You Interested In WEIGHT REDUCTION?

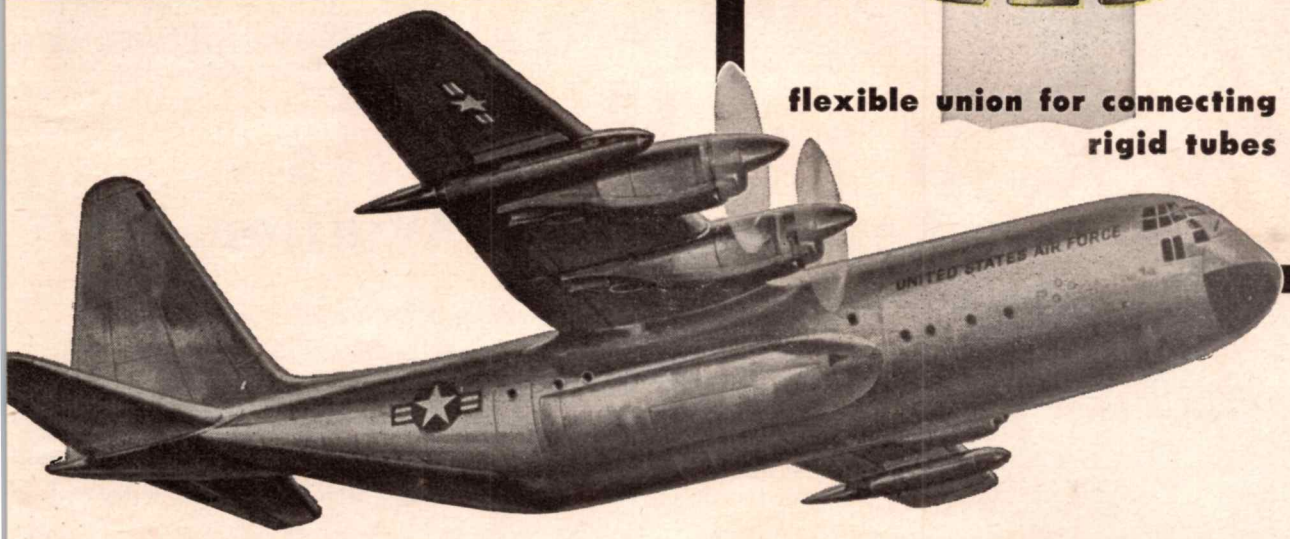
WIGGINS COUPLINGS SAVE 88 POUNDS ON LOCKHEED C-130

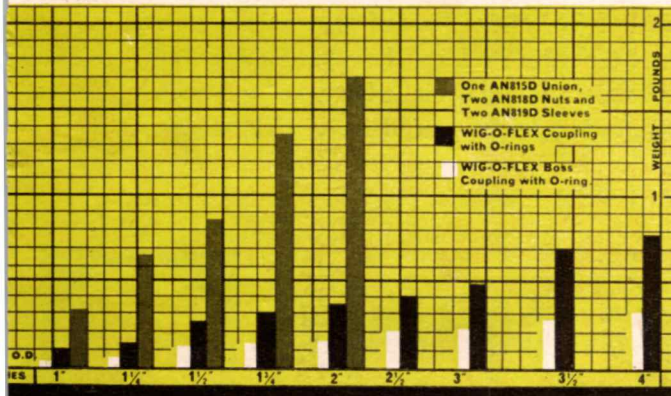
America's first turbo-prop transport—the Lockheed C-130—is 88 pounds lighter because WIG-O-FLEX Couplings replaced standard AN connections and cut hose. WIG-O-FLEX Couplings weigh 1/5 as much as the standard AN connections they can replace. (See Weight Chart for exact comparisons.)

WIG-O-FLEX COUPLING



flexible union for connecting rigid tubes





WEIGHT COMPARISON CHART
WIG-O-FLEX COUPLING & AN STANDARD FLARED TUBE CONNECTION

PROVED SUPERIOR FOR FUEL, OIL, AIR

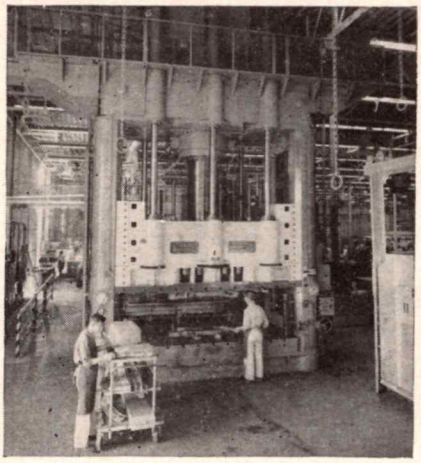
- Withstands more than 1000 psi burst pressure.
- Accommodates 4° tube flexure.
- Installs locally. 80% lighter.
- Temperature range −65°F to +250°F.

SIZES: 1", 1¼", 1½", 1¾", 2", 2½", 3", 3½", 4"

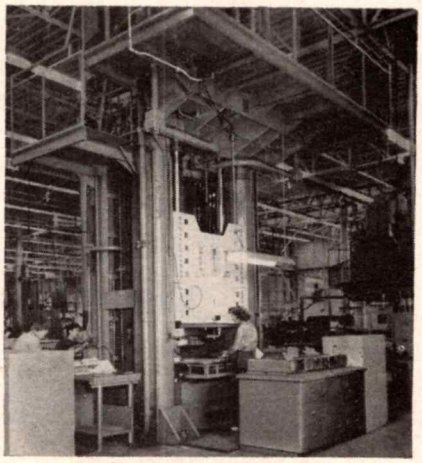
Wiggins

E. B. WIGGINS OIL TOOL COMPANY, INC.
3424 East Olympic Boulevard, Los Angeles 23, California

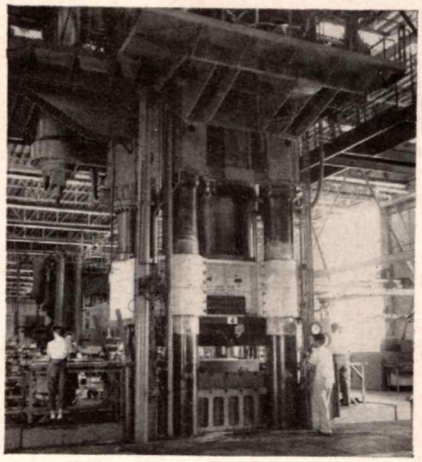
WRITE FOR FURTHER INFORMATION



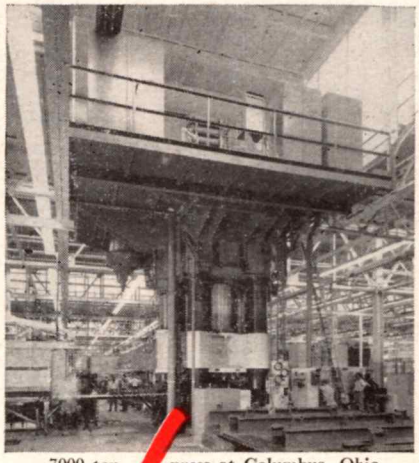
1100 ton press at Los Angeles



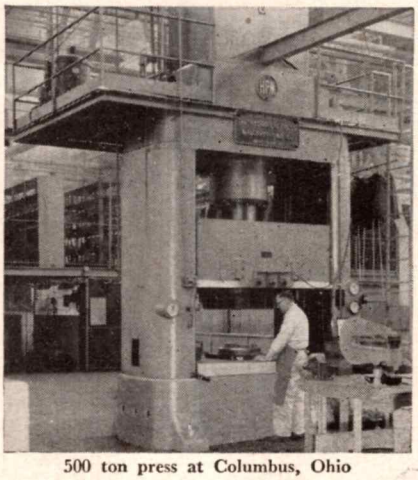
1000 ton press at Los Angeles



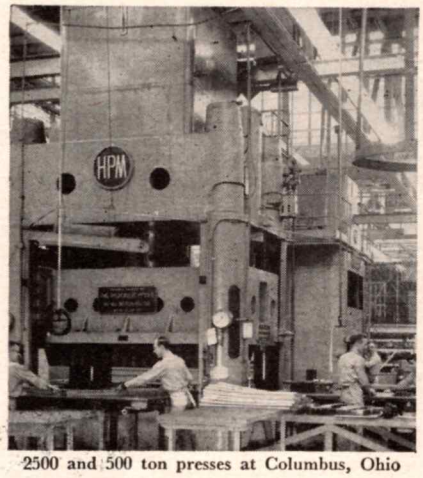
7000 ton press at Los Angeles



7000 ton press at Columbus, Ohio

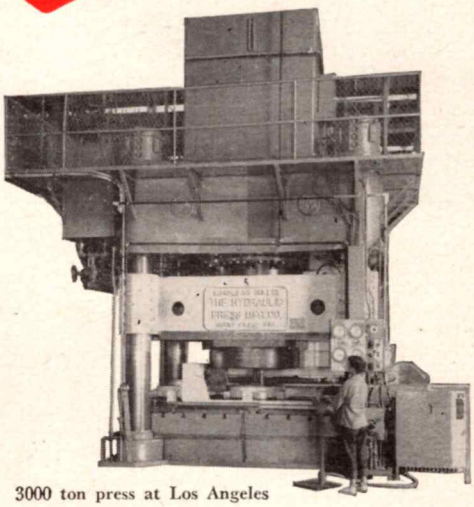


500 ton press at Columbus, Ohio



2500 and 500 ton presses at Columbus, Ohio

Look AT THE H-P-Ms at North American Aviation, Inc.



3000 ton press at Los Angeles

There's $2,000,000 invested in H-P-M presses at North American plants. And, they're a good investment! Why? Because big hydraulic press power, dependability and versatility are major factors in high production output in the aviation industry. These presses are being used for high-pressure rubber pad forming, die quenching, deep drawing, piercing and blanking . . . jobs where versatility must be "built-in", instantly adaptable to varying requirements and countless operations.

Yes, North American is just one of the airframe manufacturers depending on H-P-M presses to keep their production lines humming. For real unit cost reduction, plan your operation around H-P-Ms. Write for details or call in an H-P-M engineer, today.

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3022 MARION ROAD, MOUNT GILEAD, OHIO

HPM

AERO DIGEST
INCLUDING AVIATION ENGINEERING

VOLUME 70..NUMBER 2..FEBRUARY 1955

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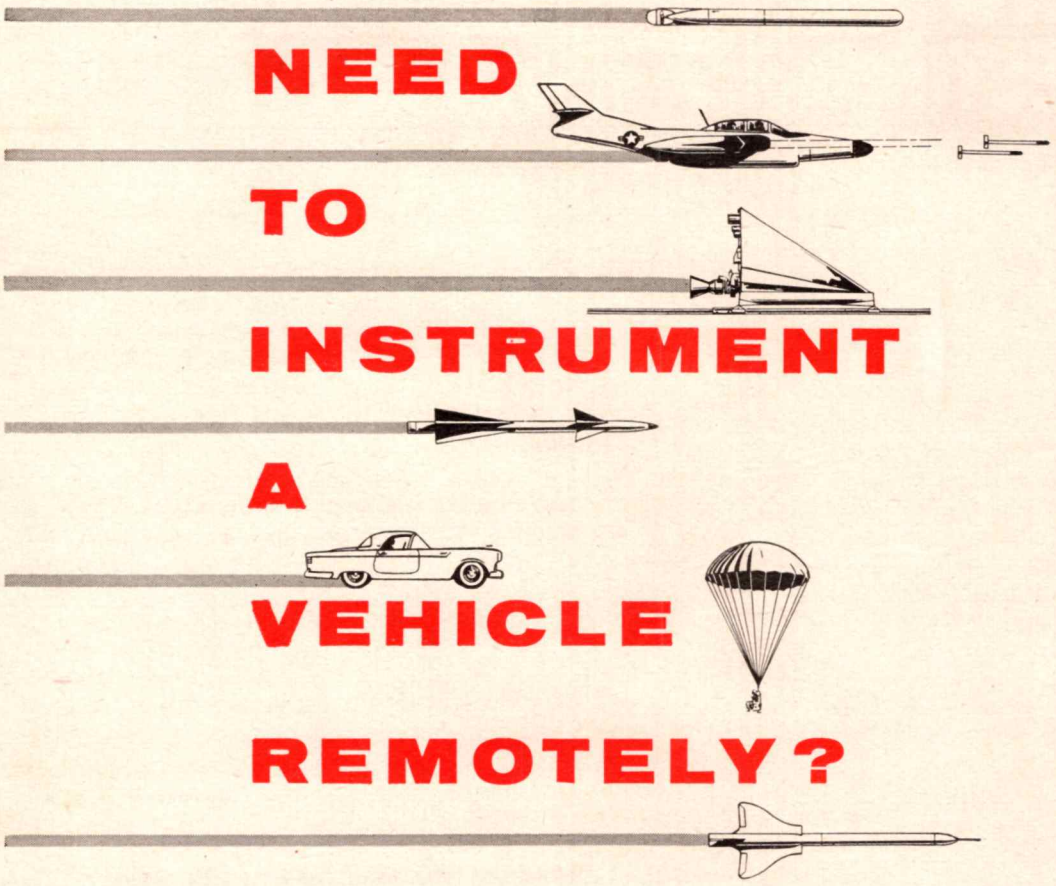
NEED TO INSTRUMENT A VEHICLE REMOTELY?



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SONAR

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TELEMETERING

ELECTRO-MECHANICAL

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Wherever time, space or weight is a vital factor in successful instrumentation, Bendix-Pacific Telemetering Systems can solve your problem.

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Bendix-Pacific Telemetered Instrumentation provides you with six distinct advantages over conventional methods.

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5. *The light weight and flexibility of the vehicular equipment permits even scale model testing.*
6. *It can save you money in both operating costs and equipment investment.*

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Canadian Distributors: Aviation Electric, Ltd., Montreal 9

Export Division: Bendix International 205 E. 42nd St., N.Y. 17

AERO NEWS DIGEST

SOME OF THE CIVIL SERVICE engineers in supervisory capacities are complaining about the raids industry is making on their junior and senior engineers. In the lower wage brackets, industry pay scales are particularly attractive to the non-supervising government engineers. The supervisors want their men's wages increased to industry levels because right now the government is in the position of competing with itself: it pays industry to lure away many of the men the government needs to guide and evaluate what industry is doing.

• • •

THE NAVY is still having trouble with the dirt in its turbojet fuel not being stopped by filters. The Detroit Testing Laboratory is having a second look at the problem. It appears that filters that are supposed to stop dirt particles over 10-microns in size are having trouble stopping even 70-micron particles.

• • •

ANOTHER VICTORY for the physically impaired was won the other day by a group of sightless workers in Georgia who had their first annual contract with Lockheed Aircraft renewed for another year. They will continue sorting out small pieces of hardware for re-use. The workers are able to salvage 60 percent of the small parts they process, parts that would otherwise have only scrap value.

• • •

"EVERY ACTION has an equal and opposite reaction" will be used by the Royal Air Force and the British Army to check where their practice bombs and shells are landing. They are planning to shoot the missiles into the sea, then determine the firing accuracy by radar which will detect the column of water raised by the impact of the missile with the surface.

• • •

TONS OF SILVER were paid to the employees of the Rohr Aircraft Corporation before Christmas. Every employee at the Chula Vista, California, plant was paid with a canvas bag containing silver dollars. Twelve-and-a-half tons of silver were rolled through the plant on trackless trains. A slip in each bag said, "Your earnings are an integral part of your life. It is fitting that you see your earnings in real cash." The surprise payoff was accepted good naturedly by employees who thought it was "quite a stunt."

• • •

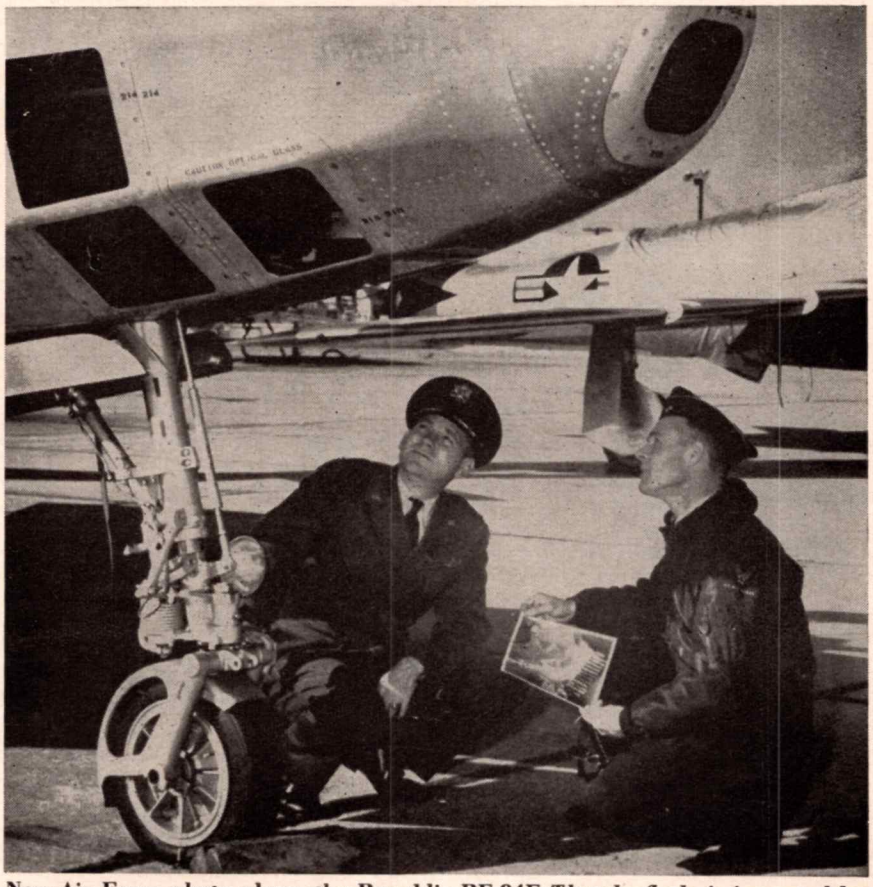
***NEPTUNE* continues to be in the news. This Lockheed aircraft, the longest-lived combat aircraft in production in the United States, has long been a prime tool of the Navy for submarine destruction. Since 1944, the *Neptune* has been re-ordered 24 times. In various versions, the *Neptune* has seen service in a variety of missions, and holds the still-existing nonstop distance record of 11,236 miles without refueling. The latest P2V-7 carries MAD (magnetic airborne detection) gear for pinpointing submerged submarines. A new order for 46 P2V-7's will extend production into 1956.**

• • •

A WIND TUNNEL for research in the transonic and supersonic speed ranges has been completed at the Cornell Aeronautical Laboratory at Buffalo, New York. Design features of the tunnel permit engineers to collect data closely approaching free-flight conditions. Speed range of the new facility is from Mach 0.8 to 2.8.

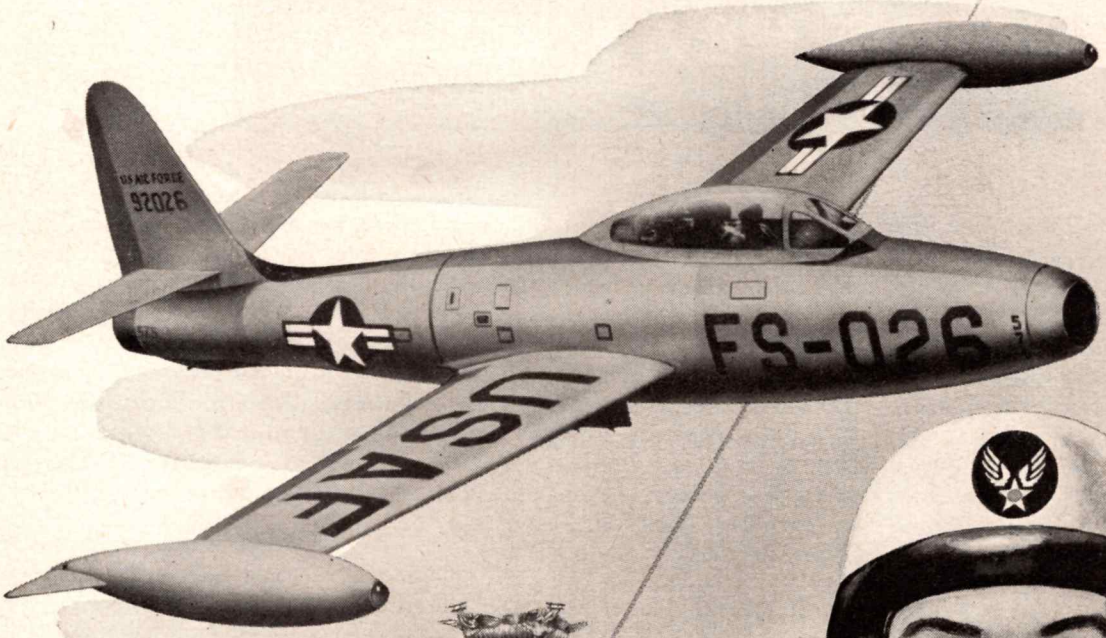
• • •

RUMORS are confirmed as fact, with the announcement that



New Air Force photo plane, the Republic RF-84F *Thunderflash*, is inspected by officers at Shaw AFB, S. C. In the more than 650 mph class the *Thunderflash* is the first modern jet aircraft specifically designed for reconnaissance work. Photo openings for top secret cameras, radar and electronic devices are visible in front and side of nose.

TO THE VICTOR...



MACKAY TROPHY
1951–1954

HARMON TROPHY
1951

GUNNERY TROPHY
1954

ALLISON TROPHY
1951–1953

BENDIX TROPHY
1949

1954
U.S.A.F.
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Republic's ***THUNDERJET!*** *In peace as in war, the skill and training of American airmen have won for the F-84 the "title" of* ***The World's Most Honored Airplane.*** *Famed as the mighty U.S. Air Force workhorse of the Korean War . . . actively serving NATO and our other allies . . . Our sincere congratulations to the USAF officers and airmen who flew or serviced the missions which gained for them these and many other awards.*

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REPUBLIC AVIATION

FARMINGDALE, LONG ISLAND, N. Y.

Designers and Builders of the Incomparable **THUNDER-CRAFT**

Ryan has been awarded a contract by the United States Air Force for the development of a jet-powered vertical take-off aircraft.

• • •

SILICONE LUBRICANTS for "hot" industries such as glass, steel, and aircraft have been developed by General Electric. The lubricants will permit design of new military and industrial equipment where thermal range of operation might be −100 degrees to over 400 degrees Fahrenheit. Jet aircraft will be particularly aided by the new material.

• • •

EMPHASIS of the military budget for 1955 will be on ". . . modern airpower in the Air Force, Navy, and Marine Corps," according to President Eisenhower's State of the Union message. The new budget, he said, ". . . accelerates the continental defense program and the build-up of ready military reserve forces."

• • •

THE NEW LOOK is announced for Cessna's 1955 Model 180. Fashion is not exclusive with automobiles when aircraft are available with harmonizing interior and exteriors in such colors as Mimosa Yellow and a choice of matching interior colors. Push-pull ventilators, adjustable seats, and convenient access to baggage are attractive features. Coupled with convenience, mechanical features such as a constant speed propeller makes the Cessna inviting to personal plane prospects.

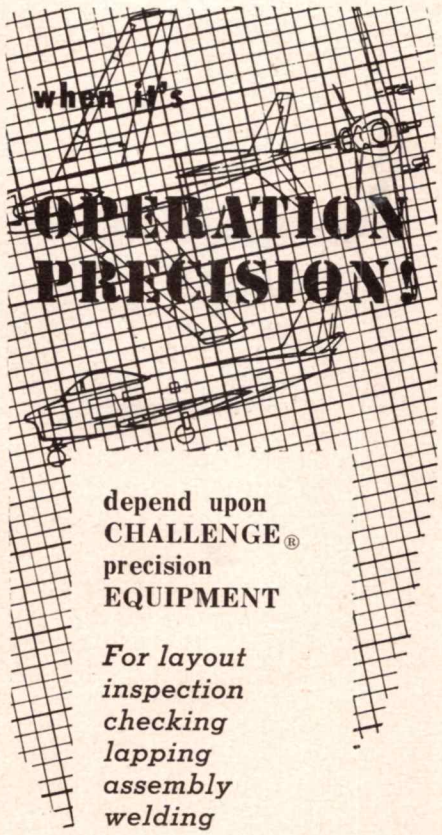
• • •

"FASTEST MAN on earth" is Lt. Colonel John Paul Stapp who traveled at 632 miles per hour and then decelerated to a stop in little more than a second. Subjected to the equivalent windblast encountered by a man ejected from an aircraft at 1000 miles per hour at 35,000 feet, the Colonel obtained first hand information from the test ride he took as part of an air crew survival project. Wearing only a plastic helmet and visor, he suffered few ill effects other than black eyes from the deceleration effects, and blisters from the dust. The project at the Holloman Air Development Center continues to investigate many phases of human tolerances to high speed bailouts.

• • •

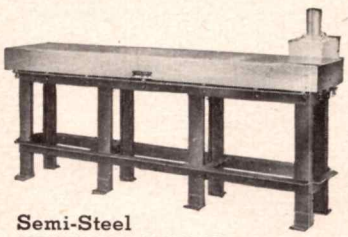
ALL WEATHER helicopter navigation operating on low frequency radio waves, without the "blind spot" or "shadow" problems of high fre-

Rocket sled being readied for a run. No protection for Colonel Stapp, the passenger, is provided. Two cameras are shown mounted on the front of the sled to record data during the run which would subject the Colonel to 35 g's load. (see above)

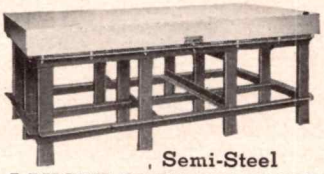


depend upon CHALLENGE® precision EQUIPMENT

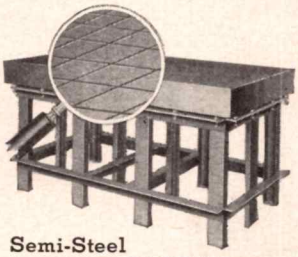
For layout inspection checking lapping assembly welding



Semi-Steel
READING TABLE
for checking propeller blades. Can be scribed or graduated to your specifications. 2 sizes. Stand is equipped with lock-leveling screws.



Semi-Steel
LAYOUT SURFACE PLATE
for layout, inspection or assembly lines. Available either precision ground or planer finished. Special leveling screws. Sizes from 12"x18" to 54"x144".



Semi-Steel
LAPPING PLATE
Assures perfect fit when lapping metal-to-metal joints on which no sealer is used. Plates have 1/16" grooves 1/2" apart. Write for bulletin F1759.

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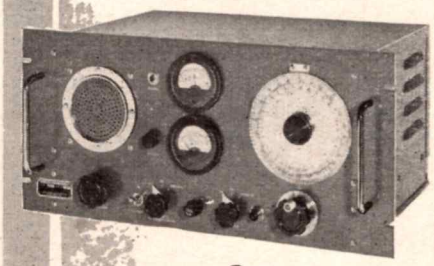

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PRECISION
ELECTRONIC
INSTRUMENTS

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FOR FULL
SPECIFICATIONS
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SILVER SPRING
MARYLAND

quency radio has solved a major handicap for these unusual aircraft. The Decca Navigator, an English system, will be made here by Bendix. No longer will the helicopter be confined in adverse weather to air traffic routes and airport approach patterns established for fixed wing aircraft. The system is as effective on the surface as it is aloft. It is used on over 2000 ships and aboard naval vessels.

• • •

AMONG OTHER PREDICTIONS of things to come, Dr. Arthur L. Klein, Professor of Aeronautics at the California Institute of Technology and design consultant at Douglas, said at the Golden Anniversary Meeting of the S.A.E. that our present instrument flying system must be replaced with something less burdensome. The pilot must be given a 3-D type of presentation so that he will have a natural view of the situation, and "Anything less does violence to his instincts."

• • •

THE CONSENSUS at Purdue University is that learning a computer's language is a *must* for scientists and businessmen who want data-processing and problem solving workloads done by an electronic brain. Sponsored by ElectroData Corporation, an 80 hour course will teach students to code, program, and actually run a problem related to their own fields. A DATATRON machine will be used for the course which starts March 7.

• • •

"AUTOMATION" is given important attention by the American Association of Manufacturers in a booklet report entitled "Calling All Jobs". The 24-page report stresses the fact that industrial machinery has undergone a continuous process of development, and that this merely has become more pronounced in the past six or seven decades. The report has been published to allay labor's fears of so-called workerless factories that would result from widespread application of automatic manufacturing processes.

• • •

A STEPPING STONE toward safety has been laid with the announcement of a visibility measuring transmissometer. The latest robot measures the amount of foreign material, dust, water vapor, or what have you, in a runway approach zone. Weather stations, often far from the exact zone where the data are needed, have been unable previously to cope with rapidly changing conditions. Evaluation of visibility, in terms of actual runway conditions, can now be given to pilots. An installation at the U. S. Air Force base in Maryland is operating, and 20 more bases are slated to receive the new weather aid.

• • •

HYPERSONIC FLIGHT conditions are simulated at the U.S. Ordnance Laboratory, White Oak, Maryland. Scientists are doing the ground-work for studies of temperature conditions of missiles in free flight. Mach numbers of 20, and temperatures hotter than the face of the sun are simulated by firing nylon balls into heavy gases.

• • •

WORLD'S SMALLEST AIRPORTS are launching Republic F-84G Thunderjets at Edwards Air Force Base, California. Aided by booster bottles used with the Martin *Matador*, a new launching technique using platforms on trucks is being investigated. Being mobile, such launchers offer a new concept in fighter plane dispersal which has great advantages in this age of atomic weapons. With the plane's turbojet engines running at full speed, the thrust of the booster bottles kicked the fighters off at a peak acceleration of four g's.

• • •

SPACE SATELLITES were, we are told, mentioned by Elwood R. Quesada, Vice President and General Manager of Lockheed's Missile Systems Division at the ground breaking ceremonies for a $4 million research laboratory at Van Nuys, California. Mr. Quesada is quoted as saying, "Even now the industry is looking forward to the development of controlled space satellites."

• • •

A BIG-LIFT was given ten prefabricated buildings when the U. S. Air Force lifted the steel structures in C-119 *Flying Boxcars* from Hensley Air Force Base, Texas, to the upper Bahamas. Assembled at the Grand Bahama Auxiliary Air Force Base, the buildings are housing avi-

ROLLS-ROYCE

have been making
propeller turbine engines
for eleven years

They make the

DART

PROPELLER TURBINE ENGINES

which power the
Vickers Viscount airliners
ordered by Capital Airlines

ROLLS-ROYCE AERO ENGINES FOR SPEED AND RELIABILITY

ROLLS — ROYCE LIMITED · DERBY · ENGLAND

AWARD-WINNING POWER BEHIND

NORTH AMERICAN'S F-100 (top) and DOUGLAS' F4D share honors in the award of the Collier Trophy in 1954. Both are supersonic. The USAF F-100 Super Sabre holds the official world's speed record of 755.149 m.p.h., set in 1953, only a few weeks after the Navy F4D Skyray had hit 752.943 m.p.h to bring the speed record back to the United States.

PRATT & WHITNEY AIRCRAFT
DEPENDABLE ENGINES

ONE OF THE DIVISIONS OF
UNITED AIRCRAFT CORPORATION

THE COLLIER TROPHY FIGHTERS

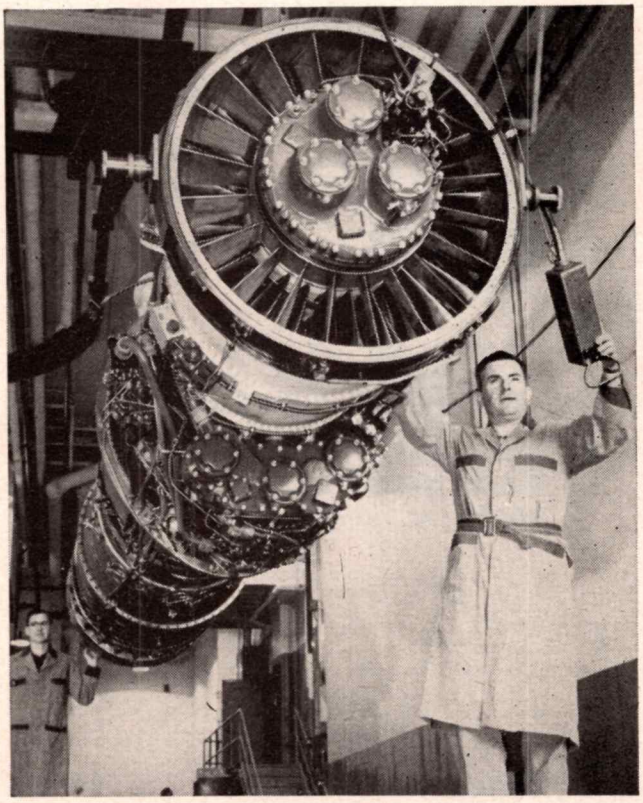
Pratt & Whitney Aircraft's J-57 engine gives supersonic speed to the F-100 and the F4D

With the 39th Collier Trophy award, America salutes two top jet fighters and the men most responsible for their design. The North American F-100 Super Sabre and the Douglas F4D Skyray are major achievements in aviation —and in U. S. Air Power.

Both Super Sabres and Skyrays are rolling from production lines to take their places in the nation's defense. And both are powered by America's highest-powered turbojet in quantity production—Pratt & Whitney Aircraft's J-57, winner of the previous Collier Trophy.

The Super Sabre and the Skyray are of a new generation of air power: a fighter generation designed from the beginning to utilize the tremendous thrust of today's high-powered engines. They are designed to fly and fight and climb supersonically . . . as their missions demand.

Pratt & Whitney Aircraft's J-57 is continuing to make its vital contributions to American air strength.



THE MIGHTY J-57—More than 10,000 pounds of thrust is provided by Pratt & Whitney Aircraft's J-57. Afterburners increase this basic thrust tremendously for short periods of operation. The engine offers outstanding fuel economy and high acceleration, vital to fighter operations, in addition to the huge thrust needed for supersonic speed. A year ago Pratt & Whitney Aircraft's J-57 was the basis for the Collier Trophy award.

Pratt & Whitney Aircraft

MAIN OFFICE AND PLANT: EAST HARTFORD, CONNECTICUT • BRANCH PLANTS: NORTH HAVEN, SOUTHINGTON, MERIDEN
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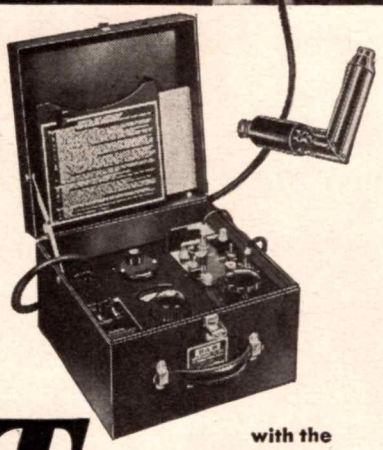

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TEMPCAL

TEST OVER-HEAT DETECTORS and WING ANTI-ICE SYSTEMS ... RIGHT ON THE PLANE!

The TEMPCAL checks thermal switch and individual thermocouple ACCURACY.

TEMPCAL *functionally tests* thermal switches with their fire detection and anti-ice systems at their *operating temperatures* right on the aircraft ... and its relay circuit makes it possible to check *switches only* on or off the plane. Additionally, using a selected part of the TEMPCAL circuit, cylinder head temperature thermocouples and their circuits to the flight deck instrument can be checked.

ACCURACY—TEMPCAL Tester temperature readings are made on a highly accurate potentiometer; guaranteed accuracy is ±5°F with temperatures ranging from 0° to 800°F. Heater probes used for cylinder head thermocouples are guaranteed accurate to ±4°C at 0° to 300°C operating temperatures.

FASTER MAINTENANCE CHECKS—It is no longer necessary to take thermal switches to the "lab" for testing. TEMPCAL probes reach a temperature of 800°F in about 8 minutes for quick maintenance checks *on the aircraft.*

The production or maintenance engineer, pilot *and cost accountant* will readily realize the savings and safety factors resulting from TEMPCAL use. We invite inquiries concerning the TEMPCAL (as well as the JETCAL ..... for jet engine EGT system accuracy) *and will be glad to have our engineering department help solve your heat problems.*

b&h INSTRUMENT

B & H INSTRUMENT
Company, Inc.
1009 Norwood
FORT WORTH 7, TEXAS

ation engineering personnel. Part of a test program, to determine the practicability of the buildings' use at advanced bases, they will serve at the Bahama outpost of the Florida long-range missile proving ground. The structures are 20 by 40 feet in size, and weigh 10,800 pounds each.

• • •

OFFICIAL NAME for the Lockheed C-130 turboprop military assault cargo plane is *Hercules*. The apt name for this craft was chosen from among 9,483 employee suggestions, and follows the well known practice of naming Lockheed aircraft after astronomical phenomena. The giant uses three-blade propellers geared to jet turbines. It takes off in one third the distance of similar sized piston engine planes. The plane promises to add unusual air mobility to the military forces of the U.S. with its ability to airlift a 5000 gallon gasoline trailer and tractor and other bulky items. (Don't look now, but wasn't *Hercules* the name of the Hughes 8-engine Duramold seaplane?)

• • •

MOVING the plane to the passenger at airport terminals was inaugurated at New York International Airport. When a plane arrives, it taxis near the terminal where cars on sunken tracks carry it to a covered loading dock. Passengers now step off planes under complete shelter of the Whiting Loadair dock. One year of trial operation at the Airport should certainly be well received by passengers coming or going through gate Number 4 at that field.

• • •

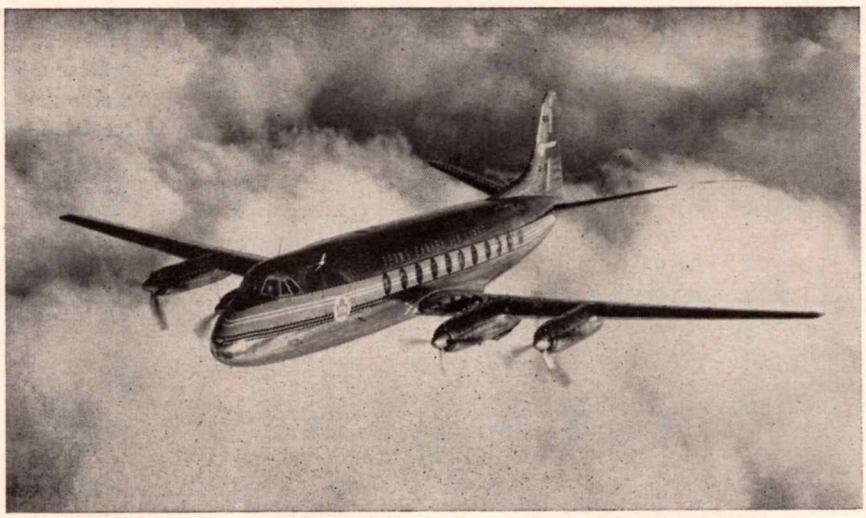
NACA CHAIRMAN, Dr. J. C. Hunsaker, has been reappointed to that post for a five-year period. Dr. Hunsaker has been a member of NACA since 1938, and Chairman since 1941.

• • •

RECENTLY A NEW NACA subcommittee on Flight Safety was formed. The new group will be responsible for problems that have been covered by the NACA Subcommittee on Aircraft Fire Prevention, and the Panel on Aircraft Survival of the NACA Committee on Operating Problems. Cognizance will be given to a fairly broad area of safety.

• • •

FIRST AIRLINE to operate a turboprop aircraft on this continent is Trans-Canada Airlines. A Vickers *Viscount* has been delivered from England as the first of 22 of the 40 passenger aircraft to be introduced to the air routes of North America. The plane differs in many respects from *Viscounts* in European service. Using an uprated version of the Rolls-Royce Dart turboprop, the R.Da.3 type 506, the aircraft has been converted to use much American flight instrumentation and radio. Fuel consumption has been reduced nine percent and the cruising speed raised 18 miles per hour to 320 miles per hour. END



First of twenty-two turboprop Vickers *Viscounts* for delivery to Trans-Canada Airlines.

First Navy Jack, which unfurled the historic warning to the world in 1775—believed to have been first hoisted to the jackstaff of the ALFRED by one Lieut. John Paul Jones.

naval history is being made today

At 0955 on January 5th, one of the major events in naval aviation history took place.

It was the unveiling of the United States Navy's great new XP6M SeaMaster—Ship No. 1 and prototype of an entirely new concept in military aircraft.

As a component of a powerful new arm of the naval arsenal—the Seaplane Striking Force—the Martin SeaMaster focuses national attention upon a revolutionary principle of military strategy, known as the WBA* concept. Here's why:

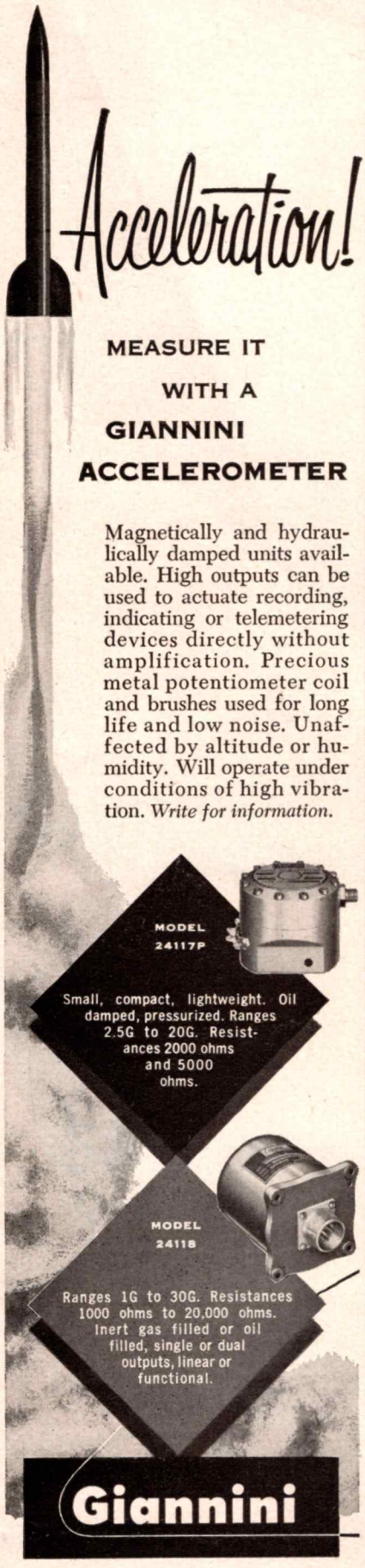
The SeaMaster is a highly versatile 4-jet waterbased aircraft, in the over 600 MPH class, which requires no fixed base and can operate from the seas, lakes and rivers, the coastal bays, lagoons and estuaries of the world... bases unlimited!

Today the top-level talk is turning to WBA... and shown here is the reason.

*WaterBased Aircraft

MARTIN

BALTIMORE · MARYLAND


Acceleration!
MEASURE IT
WITH A
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Magnetically and hydraulically damped units available. High outputs can be used to actuate recording, indicating or telemetering devices directly without amplification. Precious metal potentiometer coil and brushes used for long life and low noise. Unaffected by altitude or humidity. Will operate under conditions of high vibration. Write for information.
MODEL 24117P
Small, compact, lightweight. Oil damped, pressurized. Ranges 2.5G to 20G. Resistances 2000 ohms and 5000 ohms.
MODEL 24118
Ranges 1G to 30G. Resistances 1000 ohms to 20,000 ohms. Inert gas filled or oil filled, single or dual outputs, linear or functional.
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Airborne Instrument Division
PASADENA 1, CALIFORNIA

AERO DIGEST

Including AVIATION ENGINEERING

PUBLISHED BY THE AERONAUTICAL DIGEST PUBLISHING CORPORATION

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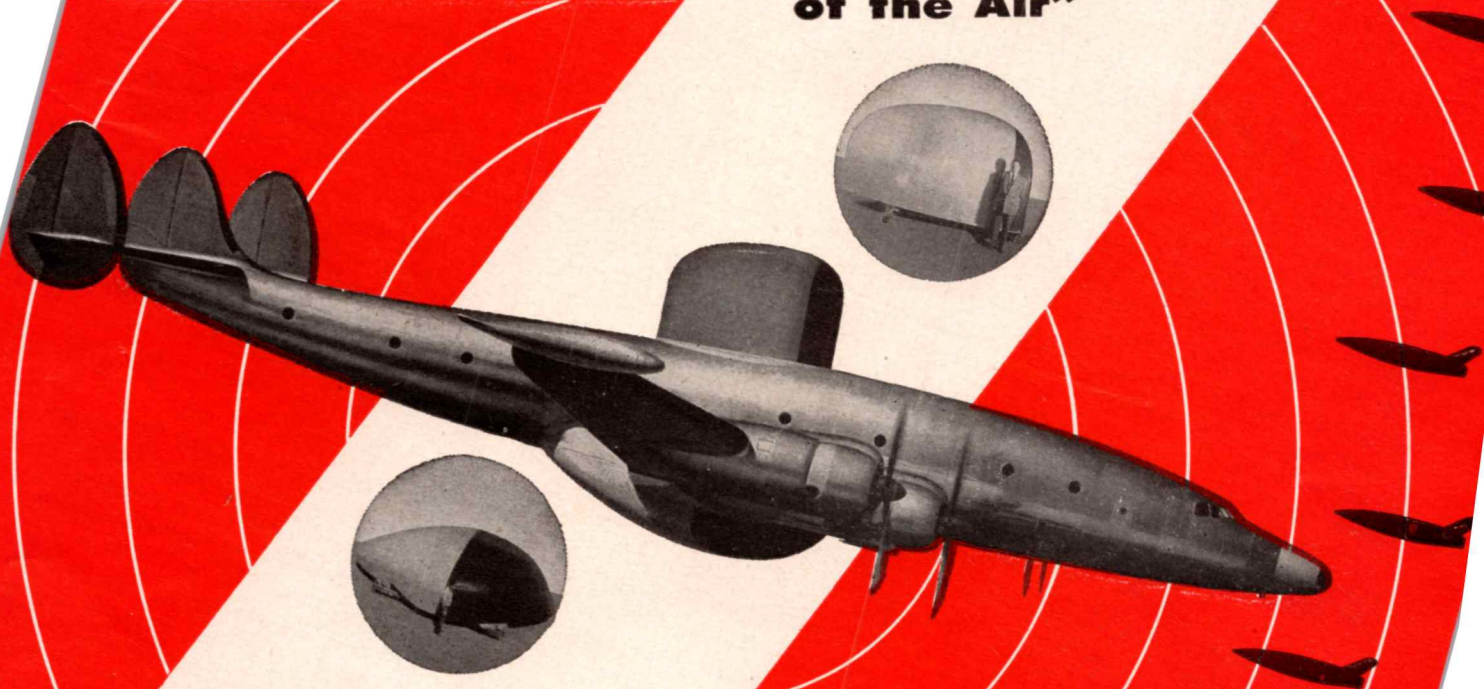
ZENITH skill produces world's largest radomes for Lockheed "Sentinels of the Air"



The huge radomes above and below the Lockheed Super-Constellation, and the novel anti-icing radome in the nose, are products of Zenith's specialized technique and skill in reinforced plastics combined with electronics. These are the giant radomes which provide 360-degree "eyes and ears" for the U. S. Navy and Air Force, scouting far beyond the borders of the United States for early warning of enemy attack.

Zenith's unique background of experience in this highly specialized field is available on contact with Engineering Department—

ZENITH AIRCRAFT *Division of Zenith Plastics Co.* **gardena, calif.**

An important announcement from General Motors to America's Aviation Industry and all who travel by air

IT has always been the aim of General Motors to supply America with the most efficient and dependable motive power for all types of transportation.

In motor vehicles, in locomotives and in many types of work and pleasure boats, GM gasoline and Diesel engines have long enjoyed the confidence of millions of people who depend upon them in their daily travels.

★ ★ ★

NOW General Motors is introducing to commercial aviation a new American-designed power plant and propeller which promise the same long step forward in passenger travel by air that GM has provided in other forms of mass transportation.

This new power plant is the Model 501 Turbo-Prop engine with matched Aeroproducts propeller, both produced by our Allison Division.

Behind each of them stand thousands of hours of military experience which has advanced engine and propeller development to a point of readiness for the passenger-flying public. This is a classic example of the benefits to the nation and the public which result from close cooperation between the Armed Forces and American industry.

Turbo-Prop power means a gas turbine engine similar to a jet, but with its tremendous power harnessed to turn a propeller.

The big advantage of the Turbo-Prop engine is that it uses less fuel than a jet, yet it enables aircraft to travel faster with *greater payload* than any other propeller-type engine.

The Allison Model 501 is the most efficient Turbo-Prop engine for its size and weight ever built in this country or abroad. It delivers more power than piston engines of twice its weight.

It incorporates all the knowledge that Allison has gained in building gas turbine engines that have *flown* more than five million hours — more flight experience than has been accumulated by any other turbine engine manufacturer — *experience in the air where it counts most.*

The military versions of the Allison Turbo-Prop already power eight different types of Navy and Air Force aircraft, including the new Vertical Take-Off Interceptors.

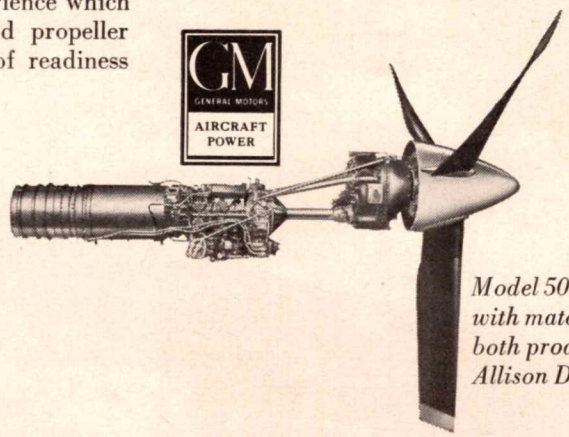
Now being readied for commercial use, the Allison Turbo-Prop will enable America's airlines to carry heavier payloads, maintain faster schedules, use shorter runways, and to offer passengers a far smoother, quieter, more comfortable ride.

While this Allison Model 501 engine can be installed in today's airplanes, the aircraft industry is busy designing new airframes to take fullest advantage of its performance.

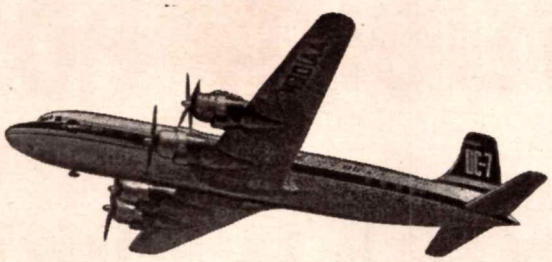
General Motors is proud that its wide experience in engine design is paying off in this important contribution to the progress of American-built-and-powered aircraft for both military and commercial service.

H. H. Curtice

HARLOW H. CURTICE
President,
GENERAL MOTORS CORPORATION



Model 501 Turbo-Prop Engine with matched Aeroproducts Propeller, both produced by Allison Division of General Motors.



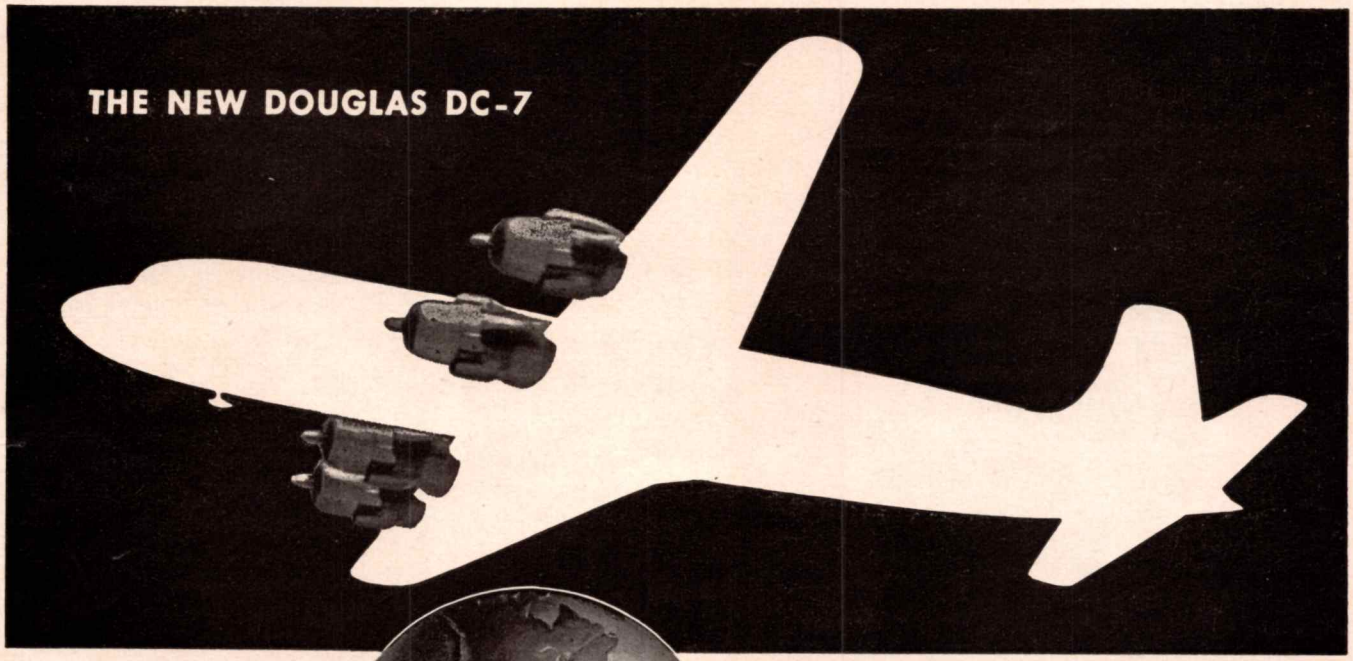
THE PROOF IS IN THE PACKAGES!

Rohr has won fame for becoming the world's largest producer of ready-to-install power packages for airplanes – like the Lockheed Constellation, Douglas DC-7, the all-jet Boeing B-52 and other great military and commercial planes.

This, we believe, is proof of Rohr's engineering skill and production know-how. But it's not the whole story.

Currently, Rohr Aircraftsmen are producing over 25,000 different parts for aircraft of all kinds... many of these calling for highly specialized skill and specially engineered equipment.

Whenever you want aircraft parts better, faster, cheaper – call on Rohr. The proof of engineering skill and production know-how is in the thousands upon thousands of power packages that have made Rohr famous.



WORLD'S LARGEST PRODUCER OF READY-TO-INSTALL POWER PACKAGES FOR AIRPLANES
-RECIPROCATING, TURBO-PROP, TURBO-COMPOUND AND JET.

ROHR
AIRCRAFT CORPORATION

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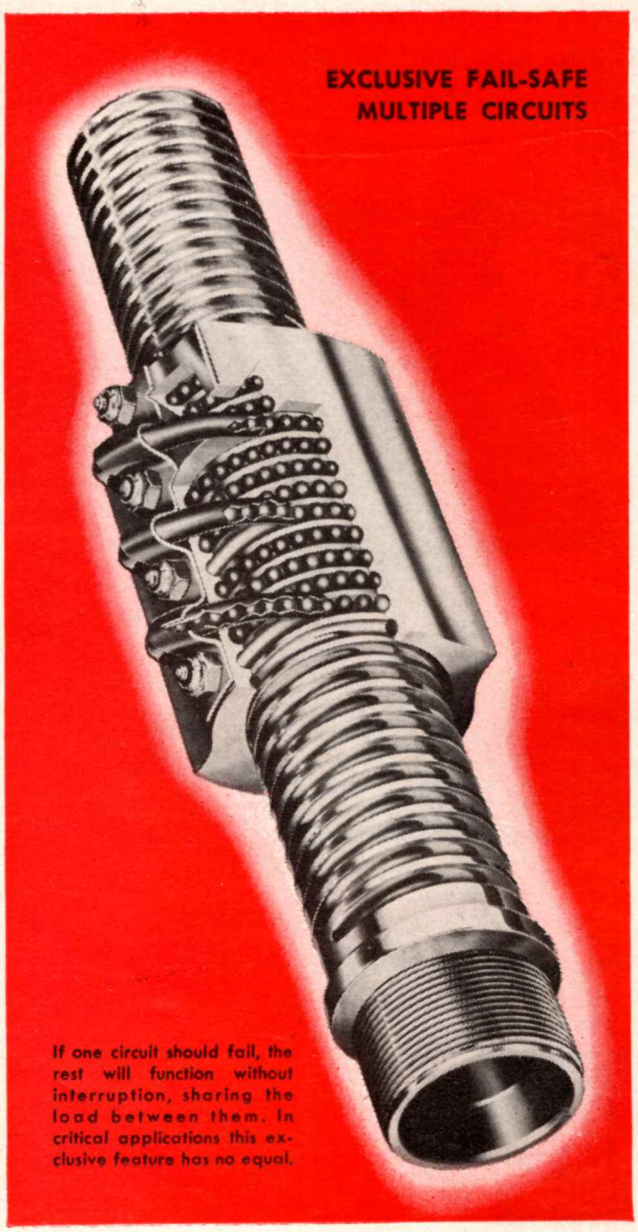
WEIGHT, POWER OR

The Safety ball/bearing Screw

can help you solve them!


EXCLUSIVE FAIL-SAFE
MULTIPLE CIRCUITS
If one circuit should fail, the rest will function without interruption, sharing the load between them. In critical applications this exclusive feature has no equal.

THERE ARE OVER 30 FLIGHT-PROVED AIRCRAFT APPLICATIONS WHERE THE SAFETY b/b SCREW EXCELS

Today a remarkably efficient actuating system, old in principle but relatively new to aviation, is being rapidly adopted by aircraft engineers as the successful solution to many actuation and control problems.

Pioneered by Saginaw to reduce automobile steering effort, the *Safety ball/bearing Screw* operates at 90% to 95% efficiency—about three times that of the conventional Acme screw. Already it has been used with outstanding success by most leading aircraft builders.

ANY SIZE FROM 1½ IN. TO 39½ FT. IN LENGTH

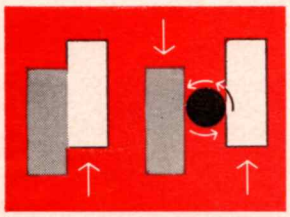
Every *Safety b/b Screw* is individually engineered for its particular application, with the wealth of know-how that only Saginaw, the pioneer, can offer. Our engineers are ready and eager to help solve your actuator problems *now*.

Safety ball/bearing Screw

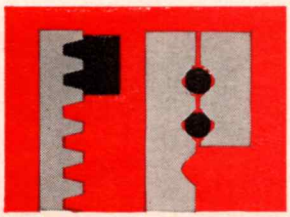
TEMPERATURE PROBLEMS?

WHAT IT IS AND HOW IT WORKS:

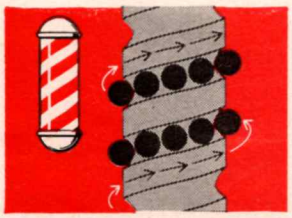
The Balls Go Round and Round and They Come Back Here!



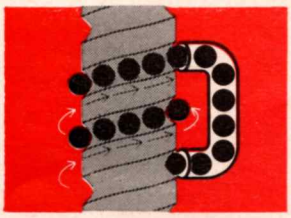
Let's start at the very beginning —with the familiar principle that there's far less friction in *rolling* than in *sliding*. The coefficient of sliding friction ranges from approximately .001 to .4—while the coefficient of rolling friction ranges from about .0005 to .003.



By applying this principle, the *Safety ball/bearing Screw* radically increases the efficiency of rotary-to-linear (or linear-to-rotary) motion. Instead of *sliding* against each other, the surfaces of the screw and mating nut glide on rolling balls.

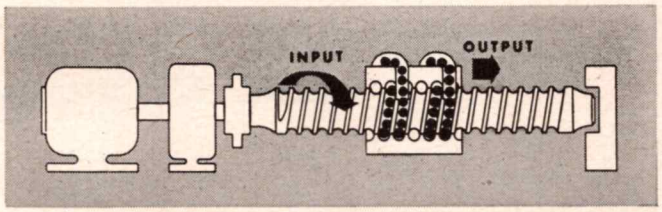


Like the stripes on a revolving barber pole, the balls travel toward the end of the nut through the spiral "tunnel" formed by the concave threads in both the nut and the screw.



At the end of their trip, one or more tubular ball guides constantly swallow the balls, lead them diagonally across the outside of the nut and back to their starting point. This forms a closed circuit through which the balls continually recirculate when the nut and screw are rotated relative to each other.

HOW IT CAN HELP SOLVE YOUR AIRCRAFT ACTUATION PROBLEMS



Compared with the conventional Acme screw's efficiency of less than 25%, the efficiency of the *Safety b/b Screw* ranges from *90% to 95%!* This makes it by far the most efficient known mechanism for translating rotary-to-linear motion, or vice versa. Combined with an electrical, hydraulic or pneumatic power source, the *Safety b/b Screw* forms an actuator with tremendous advantages for the aircraft engineer. For example, it can enable you to:

SAVE WEIGHT—compared to either Acme screw or hydraulic actuators, the *Safety b/b Screw* saves both weight and space by permitting use of smaller motors and gear boxes; eliminating pumps, accumulators, piping, etc.

SAVE POWER—by requiring only 1/3 as much torque as a conventional Acme screw for the same amount of lineal output, the *Safety b/b Screw* permits the use of much smaller motors with far less load on the electrical system.

SOLVE TEMPERATURE PROBLEMS—the *Safety b/b Screw* operates successfully at both extremely low and high temperatures, ranging from −75°F to +900°F—*without lubrication*, if necessary.

ASSURE POSITIVE POSITIONING—unlike some other types of actuators, the *Safety b/b Screw* permits precision control within thousandths of an inch, plus perfect synchronization of two or more movements.

INCREASE DEPENDABILITY—the *Safety b/b Screw* decreases combat vulnerability, offers the added security of *exclusive multiple circuits*, and reduces maintenance requirements because its "Gothic arch"-shaped races greatly decrease dirt sensitivity.

REDUCE PART AND INSTALLATION COSTS—in addition to all these design, operating and maintenance advantages, the *Safety b/b Screw* also cuts costs by permitting the use of smaller motors, decreasing power and auxiliary equipment requirements.

SEND FOR YOUR ENGINEERING DATA BOOK TODAY!

(Or see our section in Sweet's Product Design File)

It includes operating data, selection factors, design data and representative types to facilitate your preliminary planning. Just write on your company letterhead to:

by Saginaw

STEERING GEAR DIVISION • General Motors Corporation • Saginaw, Michigan

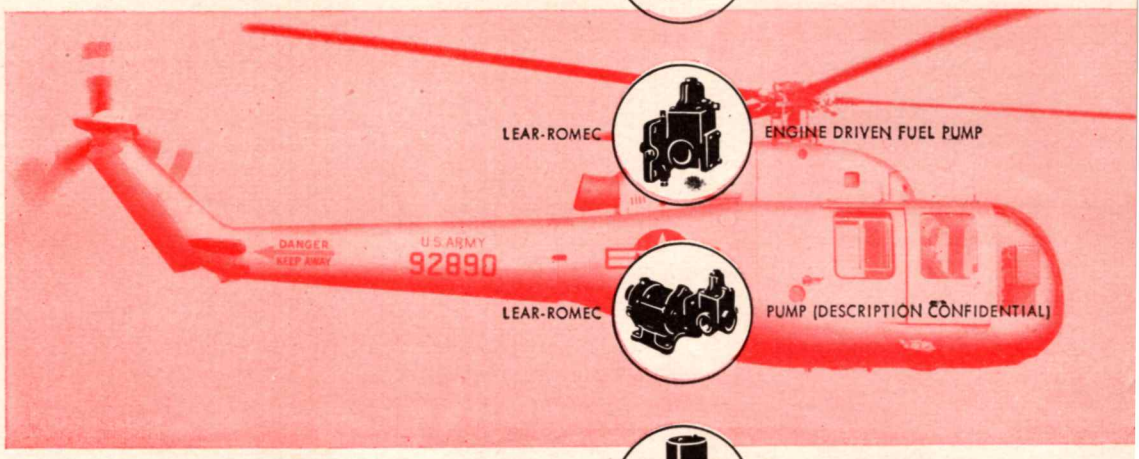
not one...

not two...

not three...but...

four...

Yes, *four* Lear-Romec pumps help the Sikorsky XH-39 set world's helicopter records for speed (156.005 mph) and altitude (24,500 ft).



LEAR-ROMEC HYDRO-MECHANICAL CLUTCH PUMP

LEAR-ROMEC ENGINE DRIVEN FUEL PUMP

LEAR-ROMEC PUMP (DESCRIPTION CONFIDENTIAL)

LEAR-ROMEC SUBMERGED FUEL BOOSTER PUMP

LEAR

LEAR-ROMEC DIVISION *Elyria, Ohio*

RO-13

EDITORIAL

WHO ARE THE EXPERTS?

AERO DIGEST
America's Premier Aeronautical Magazine
Vol. 70 No. 2 February 1955

ENGINEERS AND SCIENTISTS may have little or no interest in which armed service commands what forces and uses which weapons—but nevertheless they are deeply involved in these questions.

Two areas in which an increased degree of scientific and technical civilian participation in military decisions is essential and lacking are assessment of present and proposed weapons systems, and development of improved systems.

Best known example in the first area is the sea-air versus land-air controversy, revived recently by Field Marshal Montgomery, NATO Deputy Supreme Commander. He said that the problem of sustained flight is being solved, and with the solution air power alone will be decisive in warfare.

There was immediate reaction from the Navy. Assistant Secretary of the Navy (Air) James M. Smith, Jr., said flatly that the Forrestal-class carriers are not strategic bombardment weapons, and are not intended to be. He also said that carriers are not likely to be employed as part of the continental air defense system, and would have little if anything to do with anti-submarine warfare. He declined, however, to spell out their mission. And *The Army-Navy-Air Force Register* printed a 1947 memorandum by Rear Admiral Daniel V. Gallery, USN, then Assistant Chief of Naval Operations for Guided Missiles, recommending that the Navy sell itself, with its Forrestal-class carriers, as the primary instrument for strategic bombing with nuclear bombs—the Air Force being confined to development of an air defense system.

The Gallery memorandum, the *Register* noted, had been officially disavowed by the Navy Department, yet nonetheless appeared to have been echoed frequently by Navy spokesmen, and by some quite recently.

What is the answer? An evaluation of the two weapons systems must be made by top military talent employing disinterested civilian technical experts. In the light of national defense needs, these men must examine every aspect of cost and effectiveness of the two systems. It is not a question of the effectiveness of either weapons system, but of their relative value.

In the second area, development of improved systems, the field is broader—and swampy. It raises the big question of security restrictions on interchange of information among scientists.

A subcommittee of the House Committee on Government Operations made a thorough study of this subject, and made several conclusions inescapable. The engineers and scientists chafe under the command system of the military. Their work is far too compartmentalized under the present set-up. Civilian scientists are given too little authority. Their advice and judgment are given too little weight in the conduct of research and development programs for the military services.

One of these witnesses testifying before the subcommittee summed up with the observation that "no security system is going to create new weapons. This will come only from new ideas."

AERO DIGEST design forum WINNERS

GRAND PRIZE WINNERS AWARDED $2625

Since last August, AERO DIGEST has striven, through the competition fostered by *Design Forum*, to encourage the research, design, engineering, and production achievements of technicians in industry; at the same time, the magazine and its editors wished to give industry-wide recognition to the winners of the contests and to their works.

Judging from the large number of entries that had to be evaluated, especially during the last few months, and from industry's overwhelming cooperation, the editors feel that each objective of the contest has been notably achieved.

The judges based their decisions on the degree that the entries gave means to improve safety, reduce airplane complexity, or provide manufacturing cost saving through engineering judgment and the application of technical skill. The Board of Judges are: DR. MAX MUNK, *Chairman of the Department of Aeronautical Engineering, Catholic University;* R. J. SANDSTROM, *Vice-President, Engineering, Bell Aircraft Corporation;* A. A. VOLLMECKE, *Chief, Airframe and Equipment Branch, Civil Aeronautics Administration,* and WILLIAM BELLER, *Managing Editor,* AERO DIGEST.

The finalists and their award-winning entries are:

FIRST PRIZE—$1000

CHEMICAL MILLING PROCESS
MANUEL C. SANZ
Aerophysics Department
North American Aviation, Incorporated
Downey, California

SECOND PRIZE—$750

NAVIGATION LIGHT SYSTEM FOR HELICOPTERS
ALFRED M. BLUMENFELD
Design Group
Rohm and Haas Company
Philadelphia, Pennsylvania

THIRD PRIZE—$500

QUALITATIVE INSTRUMENT FACE
MARTIN I. KURKE
Human Engineering Laboratory
Aberdeen Proving Ground
Maryland

HONORABLE MENTION—$125

MAGNESIUM BENDING
ALFRED E. BLATTER
Tool Design Group
Rohr Aircraft Corporation
Chula Vista, California

HONORABLE MENTION—$125

FIREWALL SHUTOFF VALVE SYSTEM
WALDO DARRACQ and GLEN KAREL
Control Group; Powerplant Group
Convair, A Division of General Dynamics Corp.
San Diego, California

HONORABLE MENTION—$125

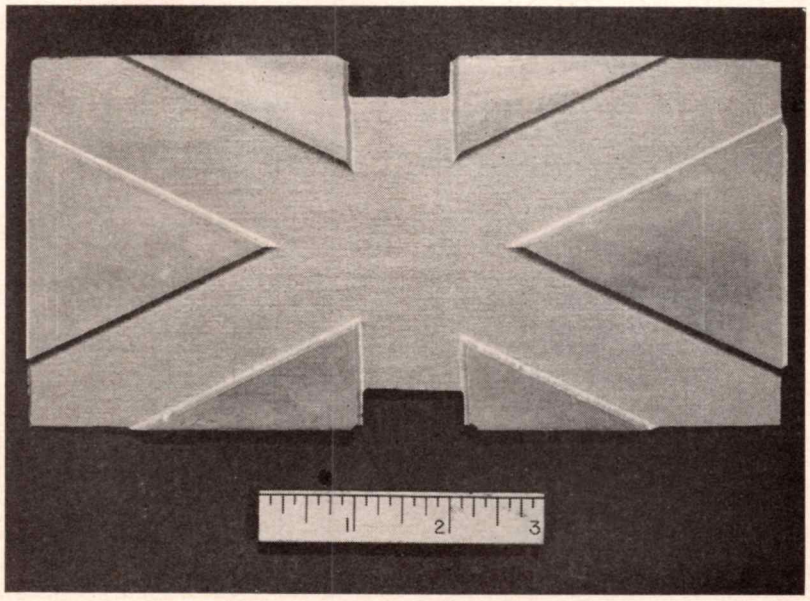
MEMORY CLOCK
LIEUTENANT COLONEL
JOHN A. DUGANNE, USAF
Joint Tactical Air Support Board
Fort Bragg, North Carolina

FIRST PRIZE • $1000

"CHEMICAL MILLING PROCESS"

Manuel C. Sanz

Manuel C. Sanz, August winner, who directed the development of a new chemical process for the precision milling of aircraft and guided missile parts without the use of machinery is the head of the Materials Research and Process Development, Aerophysics Department, at the Downey facility of North American Aviation, Inc. He holds a B.S. in Chemical Engineering and a M.S. in Chemistry and Physics from the University of Southern California.

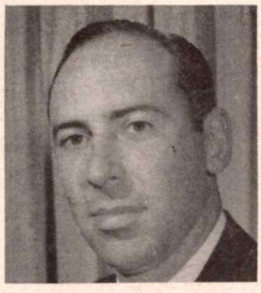


Acid-etching metals is an old process used for decades by photo-engravers. However, under Mr. Sanz' direction, North American Aviation's Aerophysics Department transformed the process into a precision-controlled metal sculpturing process. The piece to be *chemically milled* is covered in part by a protective coating to protect those areas which are to be left alone. Immersion in a modified hot alkaline solution results in removal of metal from the unprotected areas to a tolerance of 0.002 inches, compared with 0.001 inches by machine milling. The new technique removes many restrictions laid down by machine milling, and opens up many new design possibilities for aircraft designers.

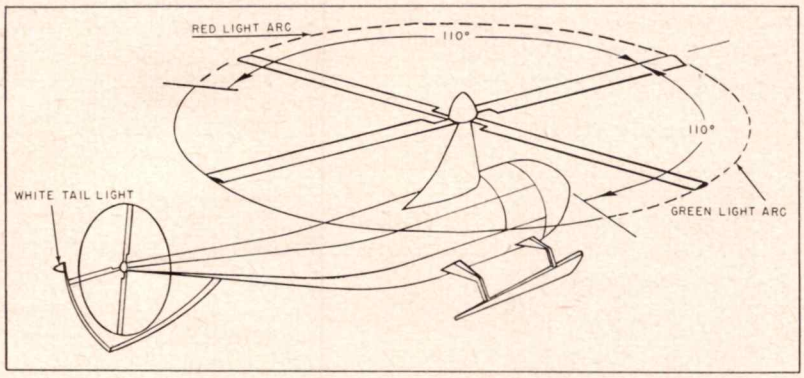
SECOND PRIZE • $750

"NAVIGATION LIGHT SYSTEM FOR HELICOPTERS"

Alfred M. Blumenfeld



Alfred M. Blumenfeld is an industrial designer and head of the Design Group of Rohm and Haas Company, Philadelphia, manufacturers of Plexiglas acrylic plastics. He is a graduate of Pratt Institute, and served nearly five years as engineering officer, operations officer and pilot on A-20, B-25 and A-26 type aircraft. He left the Air Force as a major.



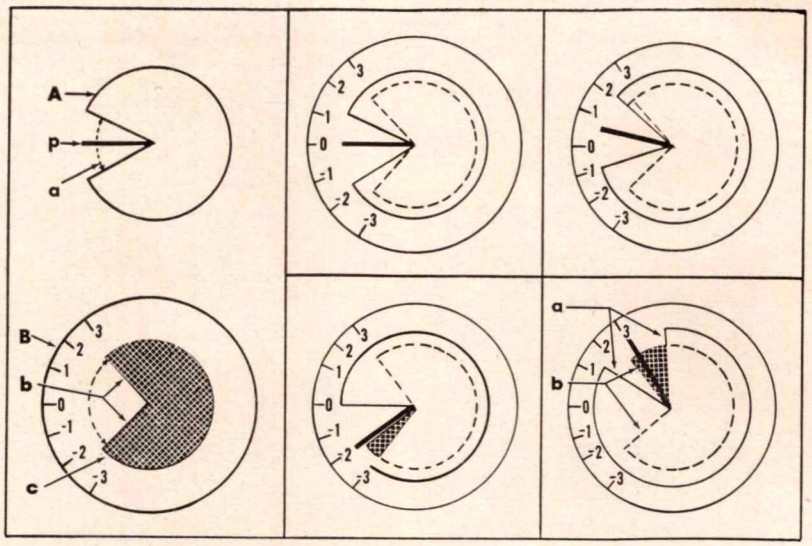
A method is proposed for locating and operating navigation lights on helicopters to permit safe flying at night, especially in and around airports. One of the proposed procedures calls for one lamp in each of two main rotor tips, one of the lamps green and the other red. During horizontal flight, each lamp will flash on when passing through an arc of 110 to 180 degrees on the side of the ship selected for that color by navigation regulations. When the craft is ascending vertically, laterally, rearward or *very* steeply forward, the green light will remain on, red one off. When the craft is hovering, descending vertically, laterally, rearward or *very* steeply forward, the red light will stay on, the green one off.

THIRD PRIZE • $500

"QUALITATIVE INSTRUMENT FACE"

Martin I. Kurke

Martin I. Kurke, September winner, is Research Psychologist at the Human Engineering Laboratory, Aberdeen Proving Ground, Maryland. He holds a B. A. degree from New York University, and an M. A. degree from the University of Buffalo where he majored in Experimental Psychology and minored in Industrial Engineering. For two years he was Engineering Psychologist at Bell Aircraft Corporation.

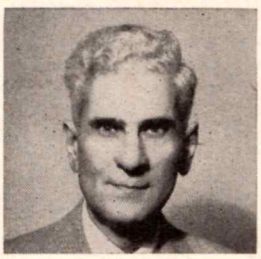


The new type instrument face was designed to simplify the task of a pilot or any machine system operator by reducing the complexity of dial display designs. This type dial indicates both quantitative and qualitative information regarding the state of a machine system. For example, any abnormal or unsafe operation within the machine system is indicated by greater than normal rotation of disc *A*, thereby exposing a portion of circle *C* which is painted fluorescent red and which serves to *flag* the human monitor. Any deviation from optimum, but within normal and safe range of operation, is shown by rotation of disc *A* (and *p*) such that the two wedges are still aligned and there is no change in color of display.

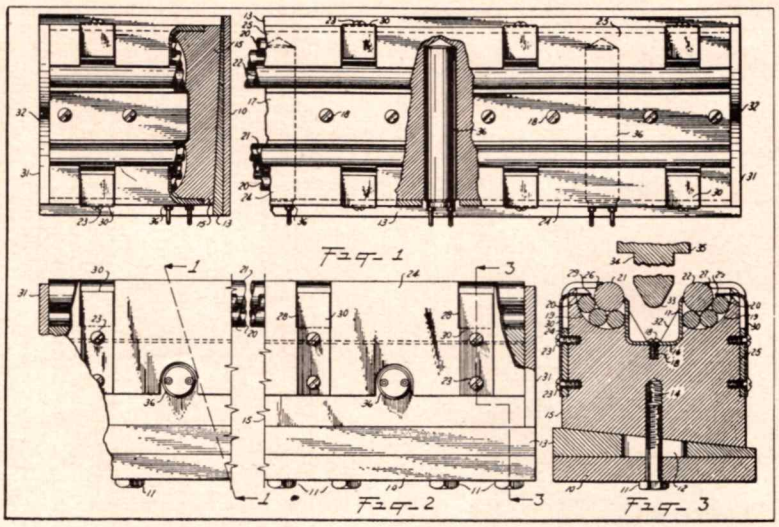
Honorable Mention

"MAGNESIUM BENDING WITHOUT SCRATCHING"

Alfred E. Blatter



Alfred E. Blatter, November winner, is a Machine Designer at Rohr Aircraft Corporation, Chula Vista, California. He has been with various manufacturing companies, including Chance Vought where he was Chief Supervisor of the job shop making manifolds for airplanes. He has also served as Chief Engineer of Eberhard Faber, and was later in charge of Machine Design at Scoville Manufacturing Company, Waterbury, Connecticut.



The contestant submitted drawings for a device to facilitate the bending of magnesium sheets in press brakes without producing scratches. In addition, his device eliminates the possibility of magnesium galling on the radii of the brake die.

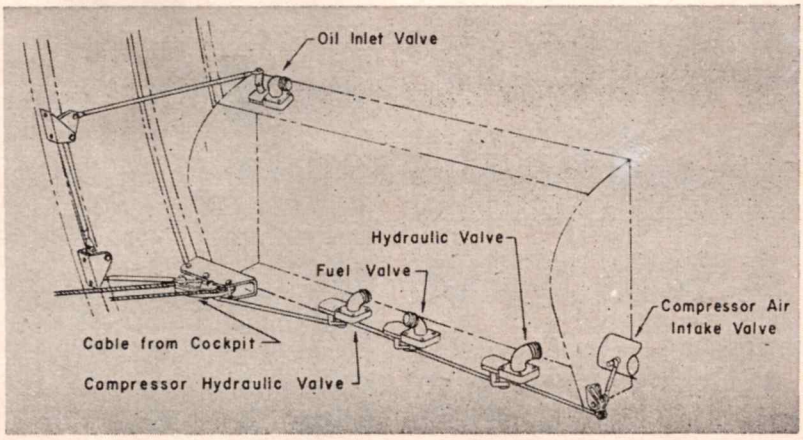
To accomplish the bending of the magnesium without scratching its surface, Blatter permits the sheets to roll free into the die by permitting feeding rollers to rotate with the materials as it is being drawn down into the die. Thus, rubbing action on the material is reduced to practically zero together with the marring of the surface. In view of the conclusions of the British Board of Inquiry looking into the cause of failure of the *Comets*, the fabrication of structures with scratch-free surfaces is of prime importance.

Honorable Mention

"FIREWALL SHUT-OFF VALVE SYSTEM"

Waldo Darracq and Glen Karel

Waldo Daracq and Glen Karel, July winners, are Design Specialists in the Control Group and Powerplant Group, respectively, of Convair, San Diego, California. Darracq holds a B.S. in Chemistry degree from the University of California. He made the preliminary layout of the F-102 control system. Karel holds a B.S. in Aeronautical Engineering. He worked with CAA in conducting full-scale fire tests on CV-340 nacelles.



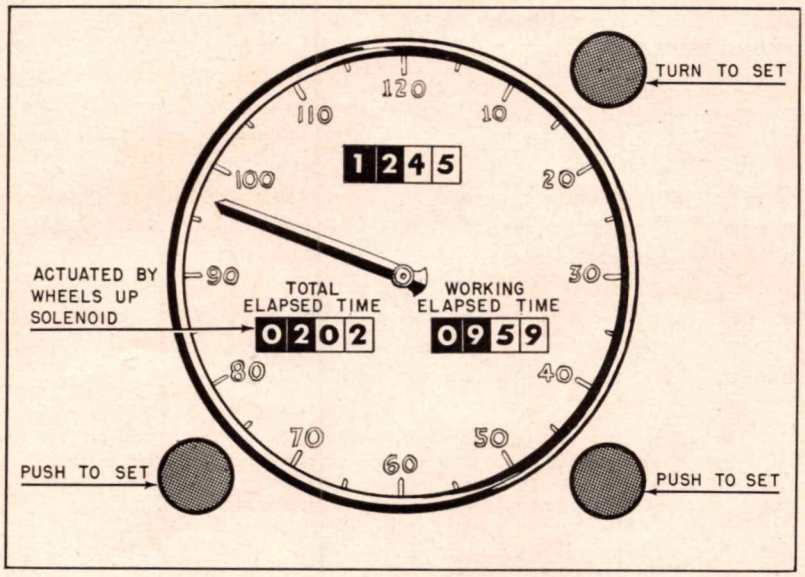
A cable handle in the cockpit of the Convair 340 is pulled and this single motion automatically shuts off all the services to the appropriate engine nacelle in the event of fire or suspicion of malfunction. The cable operates a pulley which cranks a series of push-pull rods linking together a series of shut-off valves. In the Convair 340 the cabin air conditioning compressor is located on the right engine so that the compressor hydraulic line and the compressor air intake lines must be linked to the system. Otherwise, both nacelles have a fuel line, oil line and hydraulic line shutoff valve in common. The right nacelle is shown in illustration.

Honorable Mention

"MEMORY CLOCK"

Lt. Col. John A. Duganne

Lieutenant Colonel John A. Duganne, USAF, Air Force Member of Joint Tactical Air Support Board, Fort Bragg, North Carolina, commanded 8th Fighter Bomber Squadron, 49th Fighter Group which entered the Korean War in June 1950 as one of the first jet (Lockheed F-80) organizations to see combat. After flying 90 combat missions, he was reassigned in June 1951 as Chief of Fighter Requirements for Tactical Air Command.



The Memory Clock was devised to give a time presentation that could be read quickly and interpreted easily. One veeder-root scale shows time of day, another shows total elapsed time, and another shows working elapsed time, which data provides flight personnel with the three time functions that are essential information in jet flight. The normal time indication is used in in-flight reporting. The total elapsed time is used in cruise control in all navigation. The working elapsed time presentation provides a memory device extremely useful in holding patterns, in determining reporting points, in let-down procedures, and in ILS approaches.

VERSATILE AIRBORNE RADAR

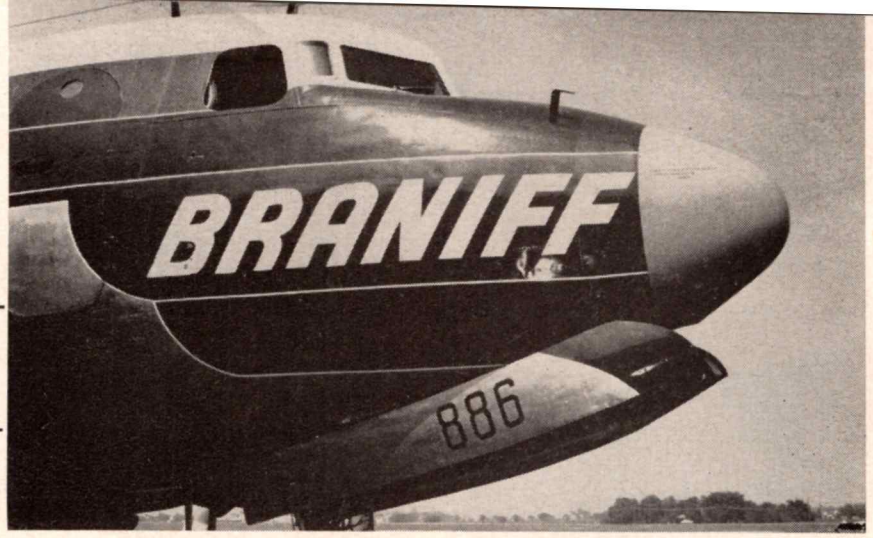


Fig. 1—Radome nose covering radar antenna installed in DC-6. The equipment warns of dangerous terrain, hazardous weather, and is a navigation aid.

FEATURES:

- **200 mile range;**
- **navigation, weather, mapping, obstacle indication;**
- **twin azimuth-range indicators.**

A DU MONT RADAR SET that can receive information from distances up to 200 miles is designed to present on its two azimuth and range indicators, information on weather conditions, topography, and "fixes" on ground radar beacons.

Promising possibilities for this set are offered for both military and commercial aviation, Fig. 1. The need for such a radar has long existed and will increase sharply as air traffic expands.

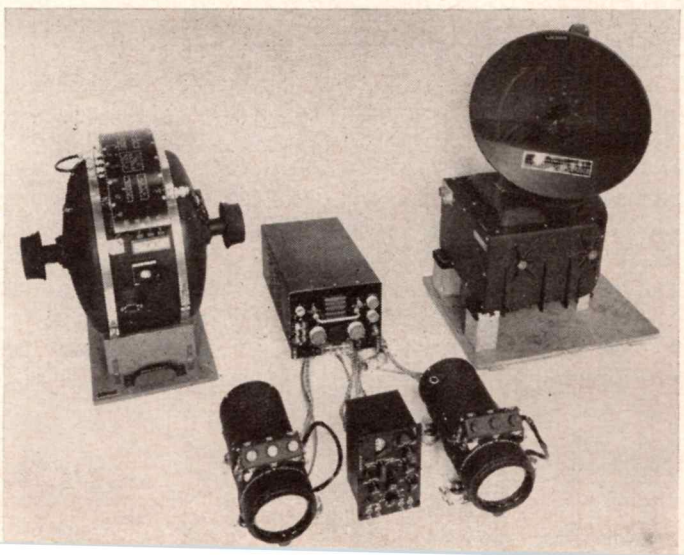
The APS 42 B radar is already used successfully in military transports. Braniff Airways is testing the unit aboard a DC-6.

The scanning antenna, mounted in the nose of the plane, emits either a fan or pencil shaped beam. Used primarily for mapping purposes, the fan beam scans the area below and in front of the plane at selected ranges up to 100 miles. The scanned area appears on the picture screen as a relief map showing cities, lakes, mountains and other terrain data. The pictures can be related readily to maps of the area under the plane.

For navigation at long or short ranges the pencil beam is used. The picture screens display coded identification signals from ground radar stations. Navigators can, therefore, obtain a *fix* of the aircraft's position. When crossing large bodies of water where ground aids to navigation are not present, navigators may *zero* on distant radar beacons by using the long range sensitivity of the equipment.

Weather detection, either of clouds containing snow, sleet, or rain, or of potential storm areas is possible. Differences between amounts of precipitation are detectable. Either beam may be used for obtaining weather information.

Fig. 2—Six major components of the radar set. Rear left, receiver-transmitter. Rear center, synchronizer. Rear right, antenna. Foreground, pilot's and navigator's azimuth—range picture screens with control panel.



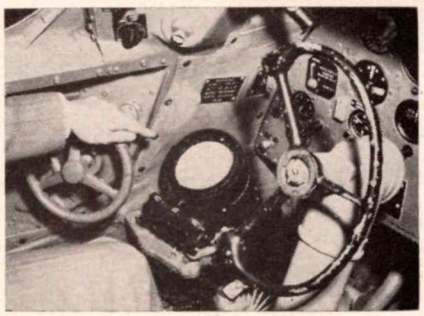
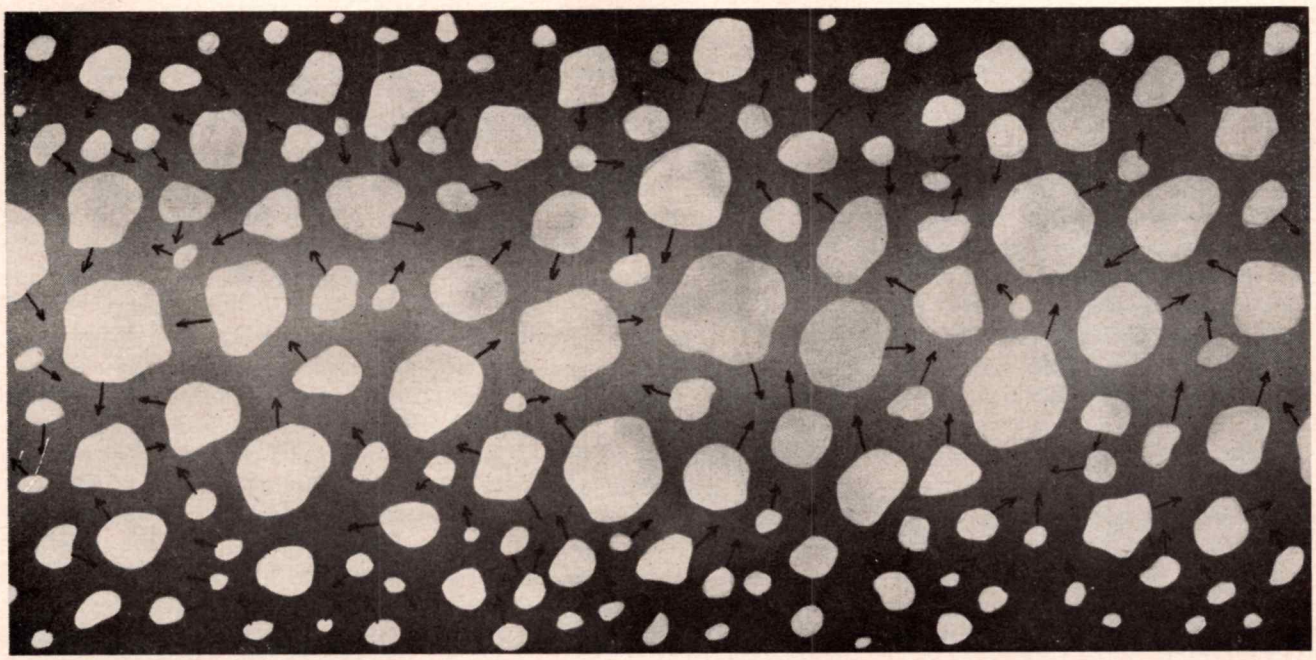


Fig. 3—One of the two azimith-and-range indicators installed in the pilot's compartment.

This radar is contained in six major components, Fig. 2. The receiver-transmitter operates from a power source of 115 volts, 400 cycles per second, and a direct current supply of 28 volts. A pulse-rate-repetition of 800 per second is used for short range (up to 100 miles) scanning. Pulse-rate-repetition for long range scanning is 200 per second.

For short range work the antenna rotates through 360 degrees at about 40 revolutions per minute for mapping. For long range, 100 to 200 mile mapping, the speed is about 15 revolutions per minute. The radar set control provides selection of a sector scanning angle in two steps, 120 degrees and 240 degrees, for weather or navigation information. From 22 to 90 looks-per-minute are given using the pencil beam in sector scanning.

A picture screen is provided for both the pilot and navigator. Each screen shows azimuth and range information. Weight of the radar system is about 200 pounds. END



Lumps in turbulent flow

DISENTANGLING TURBULENCE

To overcome weaknesses of classical turbulent flow theory Doctor Munk proposes new theory in first of a series of articles.

By MAX M. MUNK
The Catholic University of America

TURBULENT fluid motion is carried out in three-dimensional space. The time average of the flow may be two-dimensional in that the third dimension is merely repetitious, but the turbulent flow by which the actual motion differs from its time average is always three-dimensional and never two-dimensional. There exist no surfaces always and consistently occupied by the stream lines.

Spatial relations are naturally the first ones to look for when studying turbulent flow. The most elementary and casual analysis of turbulent fluid motion calls for the consideration of at least one length, varying from point to point and conveying an idea of a kind of mesh size of the turbulence pattern. The flow pattern is broken up into elements displaying at least a semblance to a recognizable pattern, and these elements have on the average a certain extension. This author has not yet found any useful way how to give a precise or mathematical definition or description of such an element of the fluid called *lump* in what follows. This does not deprive the lump size a of reality. Very many real things can not be precisely defined. Hot and cold, sweet and bitter can not be precisely defined.

• • The Lump

The lump size is the average size or linear extension of a fluid lump. The fluid lumps are constantly varying in size and are all different in size, more or less in a random fashion. The lump size a is therefore a statistical average of the linear extensions of all lumps within a certain region and moving in all directions.

The lump can be better understood if approached from two extremes. All aerodynamicists mention constantly the instantaneous velocity of a fluid at a certain point and time, carrying out a turbulent motion. The average velocity is again derived from the instantaneous velocity. The idea of an instantaneous velocity is, however, not primitive but requires comment and explanation. It has a meaning only if within a region around the point, however minutely chosen, the velocity distribution approaches uniformity. The velocity is equal to the momentum of a lump portion divided by the mass of the lump. The kinetic energy of the lump portion per unit mass must approach $\frac{1}{2}v^2$. The instantaneous distribution of the velocity v thus approaches that of constant and parallel motion. The lump elements or portions carry out a pure translational motion. The flow of the final fluid element is thus laminar and not turbulent; random character is absent or at least not measurable or noticeable. In other words, it is always implied that turbulent fluid motion is carried out by relatively small lump elements which, by themselves, move in a laminar fashion. This is seldom expressly stated and extends far beyond the Kolmogoroff proposition of isotropic turbulence within the not quite so small lump portions. For the time being, the question of different kinds of turbu-

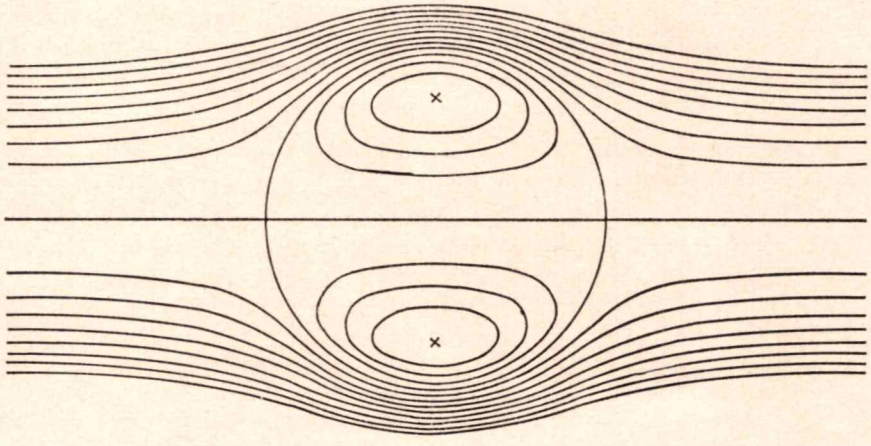
lence will be left alone. The simple realization at this point is that the smallest lump portions do not exhibit turbulence.

• • Lump Motion

As the fluid elements considered become larger and larger, the broken up character of the motion and the randomness of the flow pattern become more and more noticeable and pronounced. The time average of the motion is always laminar. However, the inquirer wants to know with what velocities the actual motion differs from the average motion that constitutes the turbulent velocity distribution. The larger the territory studied, the more positive and finally dominant is the broken up character. The turbulent fluid lump the author has in mind occupies a territory too large for one laminar fluid element and too small for one quite definitely composed of a number of broken up portions. It is the threshold between the turbulent and the laminar. Whatever the flow pattern of the lump may be, it is essentially unitary and all motions are definitely in a dominant distribution. The motion is vortical but still has a unitary architecture. The author relies on the cooperation and imagination of the friendly reader. The explanation is directed to his intuition.

The author has in mind something like a vortex ring or combination of vortex rings more or less coaxial, all rings rotating in the same sense, but their shape not being necessarily circular. The motion of the turbulence lump is otherwise random. The dominant velocity may be in any direction; the distribution and shape of the vortex loops may be of all kinds. Interest is in the average only, a type of three-dimensional variance from the laminar time average of the flow. The lump size is also random and here again only the average is considered. For the average, circular vortex rings are acceptable. The average of a three-dimensional configuration may be something new to some readers. Let him remember that it is easiest to form ideas about typical or average shapes and looks of men and animals. A photograph of a group of people is sometimes taken all on the same photographic plate, the same plate being exposed in succession to one face after the other. The composite face thus obtained, although a little blurred, appears still as a face. It is the average face of the group; that is, it emphasizes what they all have in common and suppresses individual distinctions. In the same way, this discussion deals with the average configuration of the largest fluid portions still not devoid of a unitary flow pattern. The lump moves predominantly in one particular direction and accordingly has acquired a momentum of its own over and above the momentum it contributes to the time-average basic flow as a member. That momentum, divided by the lump size, defines its velocity over and above the velocity of the basic flow.

Fig. 1—Hill's Spherical Vortex



• • Lump Shape

The lump being only an average lump, it at first seems quite admissible, at this stage of the investigation at least, to assign to it a spherical shape. To make the picture of such lump motion more distinct, it is profitable to study the so-called Hill's *Spherical Vortex.* This fluid motion is described in Lamb's *Hydrodynamics,* Section 165. It is mostly the classical potential flow of an incompressible fluid past a sphere. The novelty resided in the continuation of this flow to the inside of the sphere. The flow can be continued in a great many different ways depending on the wishes of the investigator, for inside the sphere, the condition of absence of vorticity is no longer binding. Hill required the velocity of the inside flow to blend in with the velocity distribution of the outer potential flow in a comparatively simple fashion so that the velocity is everywhere finite. He achieved this by the choice of a continuous distribution of coaxial vortex rings such that the vorticity inside the sphere is proportional to the distance from the axis of symmetry of the motion. Thus the solid sphere is replaced by a moving mass of the fluid. The flow is dynamically correct for a perfect fluid, but perhaps not stable. Viscosity effects are disregarded. The flow outside the sphere extends to infinity, but fades out rapidly when departing from the sphere. Thus the picture is not seriously impeded by filling the entire space with a large plurality of Hill's vortices, inasmuch as this discussion is of statistical averages only. There are a great many lumps, each deforms any other one slightly, and the average lump stays spherical as likely as not.

Hill's vortex is not an essential portion of this turbulence theory, for the spherical vortex flow is not necessarily the best prototype of the lump motion; but it does provide the reader with a tangible example of what to have in mind. It is not unthinkable that this happens to be a good average. A closer choice of the prototype lump motion is not necessary at this stage of the inquiry; possible differences do not yet enter the analysis. One might as well temporarily adopt the spherical vortex for reason of its simplicity.

Within the smooth time-averaged basic turbulent flow, a great many fluid lumps are accordingly travelling in all directions. They do not move as rigid bodies but possess a recognizable flow pattern giving rise to a fluid motion outside the lump core as though the lump core were

travelling similar to a rigid body. This individual travelling is subject to its own basic laws and equations of fluid motion whereby the history, life, and motion of each lump is influenced by that of every other lump, more particularly by the neighbor lumps.

• • Lump Size

How large is the lump? What picture can be formed to determine or estimate its size? Later, as the theory progresses, equations will be established leading to the answers. The equations are complicated for they involve all unknowns of the turbulent flow. It is necessary now to divide the difficulties by dispensing temporarily with these relations, and by using engineering estimates.

One thing is certain: for a flow between walls, for instance, between a pair of parallel walls or within a straight circular pipe or tube, the lump size at any one point must definitely be smaller than the shortest distance to the nearest wall (Fig. 1). The lump cannot extend beyond the wall; it must be quite smaller. Lumps statistically almost as large as their distance to the wall would not conform to the picture of many lumps travelling side by side and somewhat separated from one another through the fluid. A very large lump almost in contact with the wall is not strictly random. Also, the average must be definitely smaller than the largest lumps for which there is enough space. One can therefore definitely say that the lump size must not exceed a reasonable and small fraction of the wall distance. That fraction is denoted by $1/\alpha$ and an estimate of its size must be made. Not too much depends on the estimate since a qualitative understanding of turbulent fluid motion is being sought, and not yet one for quantitative computations. Of course, more than one estimate may be adopted, and the influence of the choice investigated.

The lump size, being a statistical average must be a continuous function of the space coordinates. The shortest distance from the wall nearby is not (Fig. 1). The reader can very easily convince himself that the plot of the shortest distance from the nearest of a pair of parallel lines has a sharp peak, not a gradual maximum. The fractions of the nearest wall distances have therefore still to be rounded off, whereby the lump size becomes smaller at the central region than the adopted fraction of the wall distance. The plot of the lump size would be curved, would be tangential at the wall to the plot of wall distances, and would be reduced in some suitable ratio. For a pair of parallel walls, the plot of wall distances forms an isoceles triangle. A parabola may be acceptable for the plot of lump sizes; accordingly, midway between the walls the ratio of the lump size to the wall distance would be only half the same ratio in the neighborhood of the wall.

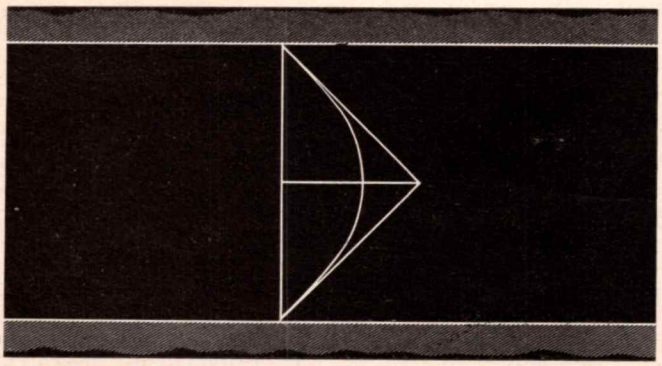


Fig. 2—Triangular plot shows "distance to wall" curve. Parabolic plot shows probable distribution of lump size.

It has not been mentioned what definite fraction appears plausible to this writer. One-eighth appears reasonable; at any rate the fraction should probably be smaller than one-fourth and not smaller than one-eighth.

• • Lump Size and Turbulence

Thus the lump size has been estimated by the mere reference to the wall dimensions. No correlation has been accepted between the lump size and the intensity of the turbulence. There is some temptation to associate more intense turbulence with a wider broken up fluid motion, so that the lump size, even with the same boundary or wall conditions, should become smaller as the intensity of the turbulence increases. The lump size may, for instance, decrease with increasing Reynolds Number. Maybe so, but this can hardly be a major or dominant effect. The lump size must be traceable back to geometrical linear lengths entering the problem. The walls or other kind of boundaries furnish that. The lump size follows certainly the wall size for equal Reynolds Number. There is no reason known why, with increasing Reynolds Number, other things remaining the same, the lump size ratio should go down and not up. At this stage of the investigation it is therefore sound to consider the variation of the lump size ratio as secondary and to disregard it, at least at first. This is evident in as much as one is dealing only with averages, and the variance of the lump size for any flow probably exceeds the variations ascribable to differences in Reynolds Number, if there are such variations at all. In investigations like the present one, all quantities have to be provisionally considered as constant unless or until good reasons have been found why they are not constant. Several different estimates of the quantity α have to be entered in any numerical analysis. That would already include some minor effect, at least of the influence of the intensity of turbulence.

This discussion brings clearly out that the lump size itself is by no means necessarily small. Turbulent flow within narrow tubes has, of course, small lump sizes. There is more room for the lumps in turbulent winds in the free atmosphere. The lump size in turbulent gas storms on the surface of the sun may be thousands or millions of miles.

In summary, the lump size is very real, but its definition is frightfully vague and the lump size, so far, can be estimated only with uncertainty. Even so, the knowledge already gained goes beyond the starting point. This knowledge shall be used to reach engineering conclusions in succeeding articles in this series.

PROPELLER DESIGN

for High Performance Utility Aircraft

By DAVID BIERMANN
Vice President and General Manager
Hartzell Propeller, Inc., Piqua, Ohio

How is the large, slowly-turning propeller with its high overall efficiency, but unreasonable diameter and weight, transformed to become the optimum propeller for a given airplane? What part does noise level play in the design?

THE CURRENT high performance utility aircraft may be powered by one or more engines of from 150 to 400 horsepower each, and have high speeds ranging from 150 to 250 miles per hour. As time goes on, these upper limits will increase.

The propellers for these airplanes have thin efficient metal blades and are equipped with mechanisms for adjusting the pitch manually, or by governor means to maintain constant engine speed. The multi-engine aircraft also have means for feathering the blades in case of engine failure. Some amphibians even have provisions for reversing the pitch for water handling. The propulsive efficiency is reasonably good, ranging from 80 to 90 percent for high speed, and providing reasonably satisfactory performance at lower speeds.

Supercharged engines are now being introduced into the low powered categories for the first time, which affect propeller designs to the extent that they must be larger to absorb the greater power at the higher altitudes. Turboprop powerplants are being considered for future designs, which may introduce new pitch control problems.

Propeller Specifications

By the time the airplane designer gets around to thinking about the propeller, the overall dimensions of the airplane are usually determined and a power plant selected, which determines the maximum propeller diameter and rpm. The propeller designer then selects a propeller, within the limits imposed by the engine and airplane, that will provide the best overall efficiency, or favor certain phases of the design. These various design phases are as follows:

HIGH SPEED OR CRUISING. The designer has little latitude in dictating the high speed or cruising blade angle once the rpm is fixed, hence, he has little control over the peak efficiency. If the engine is direct drive, the blade angle for peak efficiency probably will be around 20 to 25 degrees for current aircraft which will provide about 83-85 percent efficiency for conventional designs. For geared engines the blade angle may run up over 30 degrees, providing efficiencies approaching 90 percent. Small changes in cruising efficiency do not affect the speed materially because it takes a change of efficiency of three percent to affect the airspeed by one percent.

CLIMB OR SINGLE ENGINE CEILING. Unlike the high speed category, the climb or single engine ceiling is greatly affected by small changes in propeller efficiency. This is particularly true for heavily loaded or underpowered aircraft such as is the case for single engine operation of a twin engine airplane.

For example, if the excess power available for climbing is 25 percent of the engine power, a gain in efficiency of one percent will increase the rate of climb by four percent.

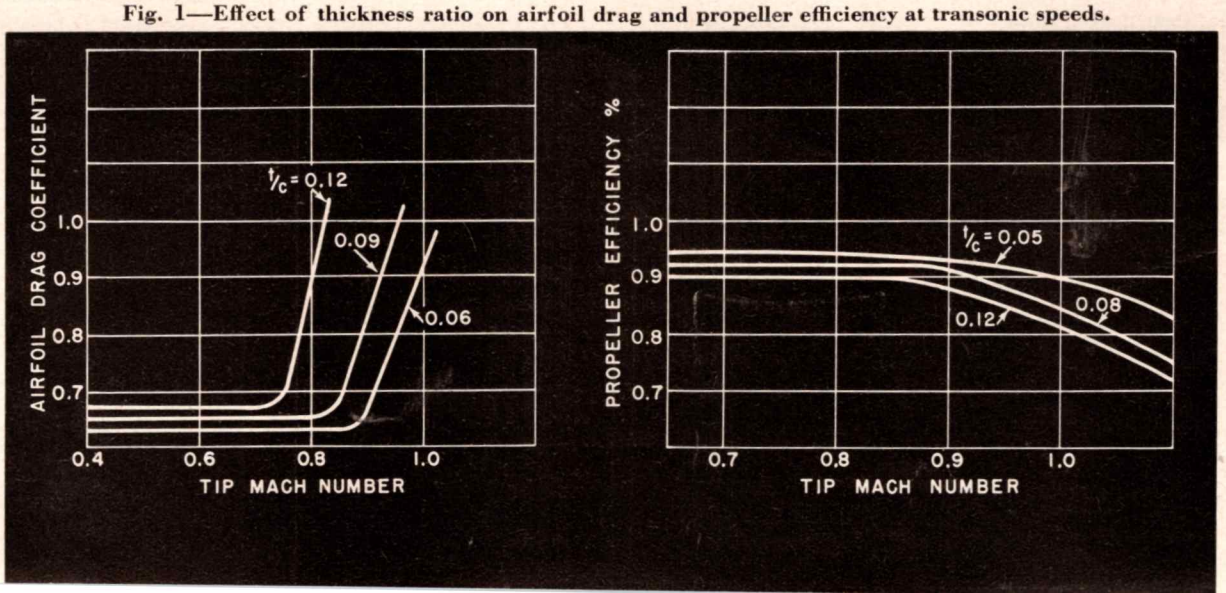
Furthermore, there is a greater possibility to increase the efficiency in the climbing range than at high speed, if the blade loading is relatively high. As will be seen later, a theoretical gain in propeller efficiency by as much as 40 percent is possible in the climbing range by using a large slowly turning propeller in place of a small high speed one that is badly overloaded. Such a gain would increase the climb of the above underpowered example by 160 percent.

TAKE-OFF. In general, the factors that make for good single engine ceiling or climbing rate also make for good take-off, as the length of the take-off run is largely determined by the efficiency existing at the latter part of the take-off run.

In the case of seaplanes the thrust at the minimum planing, or *hump* speed is the most critical. If the

** Based on an S.A.E. paper delivered November 12, 1954 at Wichita, Kansas.*

Fig. 1—Effect of thickness ratio on airfoil drag and propeller efficiency at transonic speeds.



thrust is insufficient to get the float on the step, the take-up run is infinite. As float resistance in the water is very sensitive to loading, it follows that the load a seaplane can get off with usually depends upon the thrust available at the minimum planing speed.

Aerodynamic Factors

The dimensional characteristics of a propeller blade are defined by thickness, width, and pitch distribution, as well as airfoil sections. The thickness ratio is by far the most important design parameter other than size, as the propeller tip sections are usually operating only slightly below the transonic range.

The effect of thickness on drag and propulsive efficiency are given in Fig. 1. It may be seen that for aluminum blades having a thickness ratio of 0.05 at the tip the effect of compressibility becomes apparent at speeds over 0.9 Mach Number. For thicker blades, such as those made from wood, the effect of compressibility becomes noticeable sooner, particularly if the metal leading edge reinforcements are not inset flush with the surface.

Flight tests have indicated increases of 10 to 15 percent in peak efficiency as the result of replacing wood or plastic blades with thin metal blades. Insetting the metal tipping of wood or plastic blades flush with the surface reduces these differences to about half.

The effects of round or thick blade shanks on efficiency may be as much as 15 percent, depending on the body, and extent of the poor section. The addition of a spinner reduces the shank and hub drag, resulting in efficiency gains of 3 to 10 percent.

For the airfoil section, a compromise may be made between one having delayed compressibility, good maximum lift, and ease of manufacture. The thickness ratio can be reduced if the blade width is increased, almost proportionately; thus wide blades have a higher critical Mach Number than narrow ones, and lower drag coefficients.

The blade width or activity factor, and number of blades are design parameters that depend upon factors such as diameter, power, rpm, design airspeed and altitude, and should be adjusted to provide the desired overall performance.

The pitch distribution is generally a compromise between the requirements for take-off, climb, and high speed.

Summing up the factors entering into an efficient propeller design, the designer finds that the optimum propeller for the high performance utility plane should have:

a. Thin metal blades.

b. High speed sections near the tip selected for good overall characteristics.

c. Low drag shank sections exposed to the air.

d. Spinner large enough to house the hub and poor sections.

e. Optimum blade width and number of blades.

f. Optimum pitch distribution.

Structural Factors

Weight is particularly sensitive to increased size when solid metal blades are used, and aluminum probably provides the best material at this moment. In scaling geometrically similar propellers, one finds that the weight increases a little less than the cube of the diameter. If the blade width is increased the blade weight increases about proportionately, as the thickness may be held about constant.

The large slowly turning propeller which would result in high overall performance appears impracticable for most applications. There is a possibility of utilizing lighter materials, such as magnesium, but development in this direction probably will be slow.

Noise, Vibration Factors

Fig. 2 shows the approximate relationship between tip Mach Number and the generation of noise for two- and three-bladed propellers.

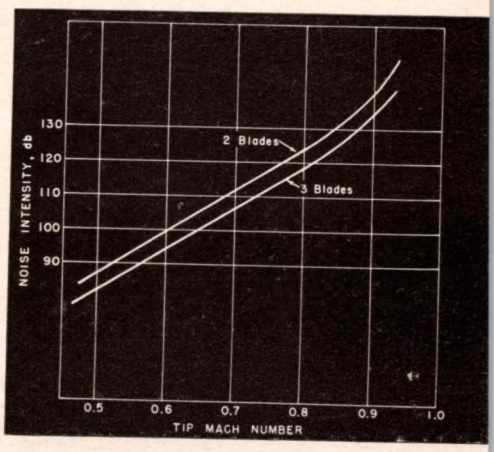
As seen from Fig. 2, the use of a three bladed propeller offers an attractive opportunity to reduce noise without any appreciable sacrifice in performance, because the propeller can be smaller in diameter and because it is inherently quieter. For example, recently a twin engine executive airplane that was equipped with two bladed propellers of 90-inch diameter was refitted with three bladed propellers of 74-inch diameter. Measurements in the cabin indicated a reduction of 15 decibels for frequencies in the speaking range, which bears reasonable relationship to the results shown in Fig. 2.

The location of the propeller with respect to the cabin also has an important bearing on cabin noise. The greatest noise intensity is in the plane of the propellers. Furthermore, the pulsations from the slipstream can set up vibrations in the airplane structure which in turn will create noise. In the above example, the three bladed propeller resulted in substantially less drumming of the side of the fuselage because of greater blade clearance, less energy per blade, and a frequency excitation that was above the natural frequency of the fuselage wall.

Three bladed propellers also appear to be inherently smoother than two bladed ones, possibly because of the former's greater flywheel effect which affects the engine smoothness, and also possibly because any gyroscopic couples are linear instead of sinosoidal as is the case for two bladed propellers.

To what extent noise generation from propellers should be reduced is difficult to answer because the price to be paid may be high if the specifications are severe. It seems likely that the standards of comfort will rise gradually from year to year, giving the airplane designer the opportunity to investigate every angle without the necessity of jeopardizing other aspects of the design.

Fig. 2—Approximate noise generation for two- and three-blade propellers.



Examples

In order to illustrate the various design compromises one must face in selecting a propeller for a given airplane, it is best to start with the ideal

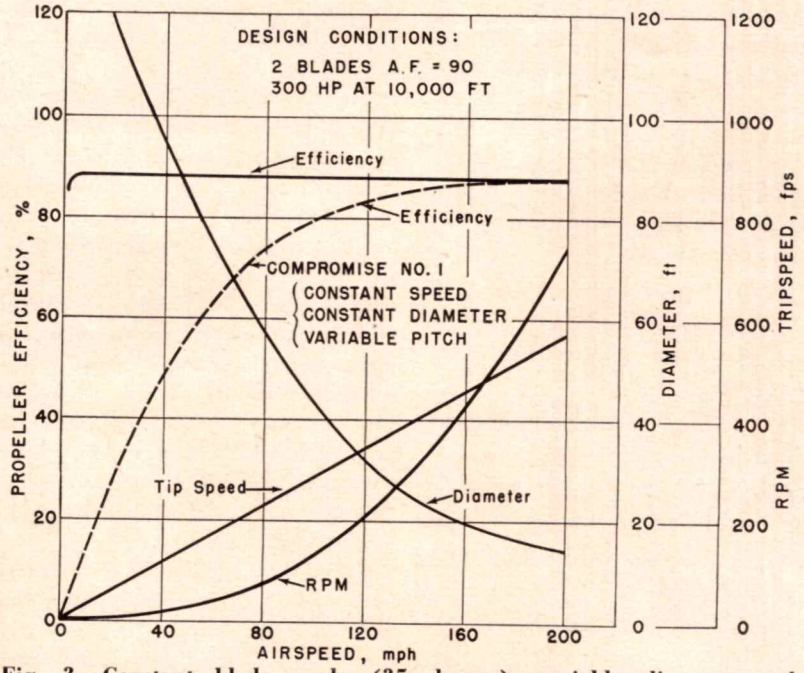


Fig. 3—Constant blade angle (35 degree), variable diameter and gear ratio to obtain maximum efficiency throughout flight speed range.

aerodynamic solution and then resolve it into several solutions.

First, assume an airplane-engine combination:

High speed: 200 miles per hour at 10,000 feet.

Power plant: 300 horsepower from sea level to 10,000 feet.

Gear ratio: to be selected.

The maximum peak efficiency of a propeller occurs when the blade angle is set slightly less than 45 degrees (usually around 35 degrees from tests), and at a V/nD value of about 1.6. The ideal propeller, therefore, will operate at all flight conditions at these constant values of blade angle and V/nD, resulting in an efficiency of about 88 percent.

In order to operate at constant V/nD and blade angle for all air speeds it is necessary to vary the gear ratio as well as the diameter. Fig. 3 shows curves of efficiency, diameter, rpm, and tip speed plotted against airspeed for the 200 mile-per-hour airplane.

Note that the diameter varies from 15 feet for the high speed end of the range to infinity for the static condition; while the rpm varies from 750 at 200 miles per hour to zero for the static condition. The efficiency, of course, remains constant at 88 percent. Tip speed, while never high, is proportional to airspeed.

The one lesson to be learned from this illustration points out the importance of large diameters in obtaining high efficiency at low speeds.

Of course, such an engine-propeller combination is not feasible from several standpoints; so the designer must seek a more practicable solution with fixed diameter, controllable pitch propellers.

The first compromise propeller from the ideal aerodynamic one is a propeller having a constant diameter of 15 feet, in order that it may operate at high speed (and cruise) at 35 degree blade angle, thereby providing an efficiency of 88 percent. Such a propeller would rotate at a constant rpm of 750, and provide the efficiency curve shown as the dotted line of Fig. 3. It will be seen from later curves that not only is the high speed efficiency the highest obtainable, but that at all airspeeds this efficiency curve is the highest obtainable for a propeller in the feasible structural category.

Unfortunately, the 15 foot diameter, the 480 pound weight, the 750 rpm, make this first compromise propeller also impracticable for most designs. If one were to design a special purpose airplane intended to excel at low speeds he could approach these design requirements: however, in compromise Number 2 (Fig. 4), the diameter is arbitrarily limited by clearance considerations to 8 feet, and the tip speed at high speed is limited to 0.9 Mach Number.

With a two bladed propeller, the high speed efficiency is reduced by three percent, resulting in a loss in speed of only one percent; but the loss in take-off and climb would probably be of the order of 20-30 percent, depending on the airplane loading parameters.

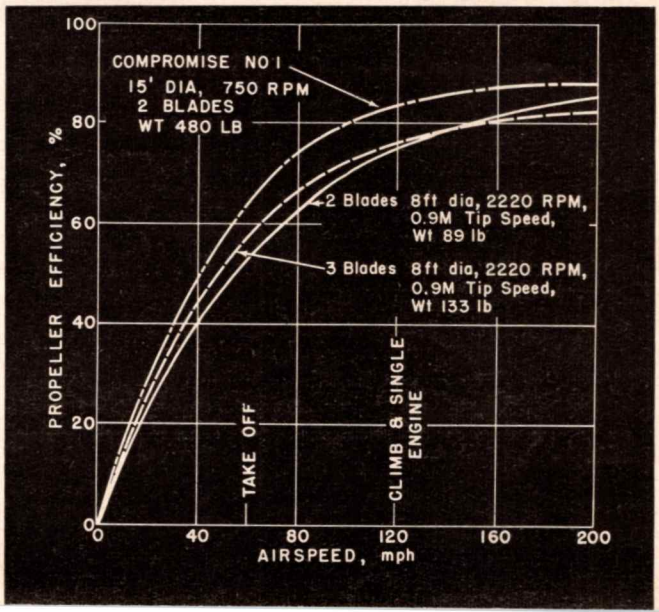
Replacing the two bladed propeller with a three bladed one, the designer would find that the take-off and climb would improve.

In order to reduce noise, a tip Mach Number of 0.8 is assumed as the upper acceptable limit labeled as compromise Number 3 in Fig. 5. In this case the rpm drops to 1970 from 2220 but diameter remains at 8 feet. The two bladed propeller is overloaded throughout the low speed range, requiring either a three bladed propeller having normal blade width, or a three bladed propeller having wide blades.

In compromise Number 4 the rpm is held constant and the diameter is reduced from 8 feet to 7.1 feet in order to reduce the maximum tip speed to 0.8 M., Fig. 6. Again, the two bladed 90 A.F. propeller becomes even more overloaded than in the previous case, so it is necessary to

Continued on page 37

Fig. 4—Compromise Number 2. Propellers limited to eight foot diameter, 0.9 Mach Number Tip Speed, 2220 rpm.



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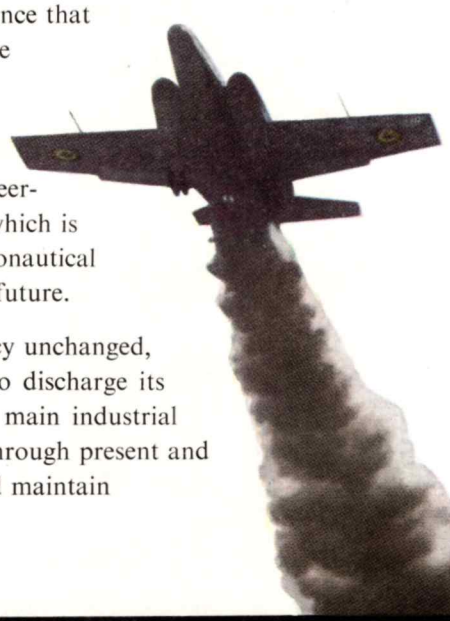

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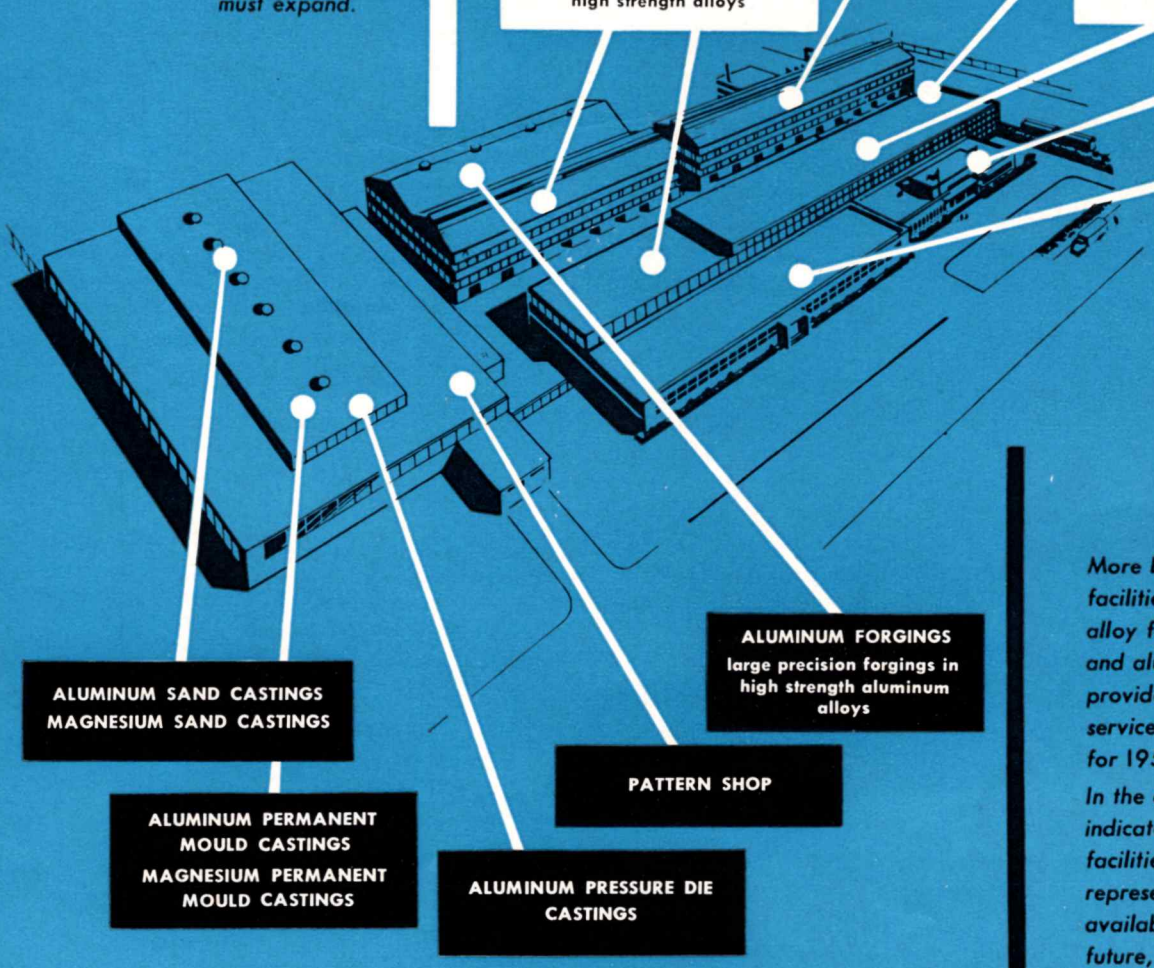

More buildings—increased facilities to produce large, light alloy forgings—magnesium and aluminum foundries to provide a complete casting service—are all planned for 1955.

In the diagram, white panels indicate present C.S.I. facilities. Black panels represent facilities to be available in the very near future, including extensions to present laboratory and engineering departments.

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increase solidity in order to achieve reasonable take-off and climb performance.

Comparing the two methods for reducing tip speed, the designer can see from Fig. 5 and 6 that reducing rpm is preferred, from the efficiency standpoint, to reducing diameter; although the differences are not great. Reducing diameter does have the practical advantage of increasing clearances and reducing weight.

The question arises as to the penalty for not gearing the engine. In compromises Numbers 5 and 6, the rpm is limited to 2600 and the maximum tip speed limited to 0.9 M and 0.8 M, respectively. This results in diameters of 6.8 and 6.0 feet, respectively.

From Fig. 7 and 8, each design becomes higher loaded than for comparable geared installations, necessitating higher solidities.

Several conclusions can be drawn:

1. The maximum overall efficiency is obtained by a large slowly turning propeller of low activity factor, designed such that maximum efficiency occurs at the peak of the envelope efficiency curve, in the region of 35 degree blade angle. Such a propeller may not be practicable because of excessive weight and diameter.
2. Reducing the diameter and increasing the rpm to practicable dimensions results in losses in efficiency throughout the flight range, depending upon how far this process is carried.
3. This process eventually necessitates compensating for loss in diameter by increasing the solidity of the propeller. Increasing solidity, however, never quite compensates fully for a loss in diameter, although the overall design might be preferable for other reasons.
4. Reducing the tip speed in order to reduce noise may be accomplished by either reducing the rpm or reducing the diameter and keeping rpm constant. In either case the solidity must be increased to compensate. Reducing the rpm appears to be preferable from the efficiency standpoint, but reducing the diameter is probably more practicable.
5. Increasing the number of blades from two to three is desirable in reducing propeller noise even though the tip speed remains constant. Three bladed propellers are inherently smoother than two bladed ones, hence are desirable because of the comfort factor. END

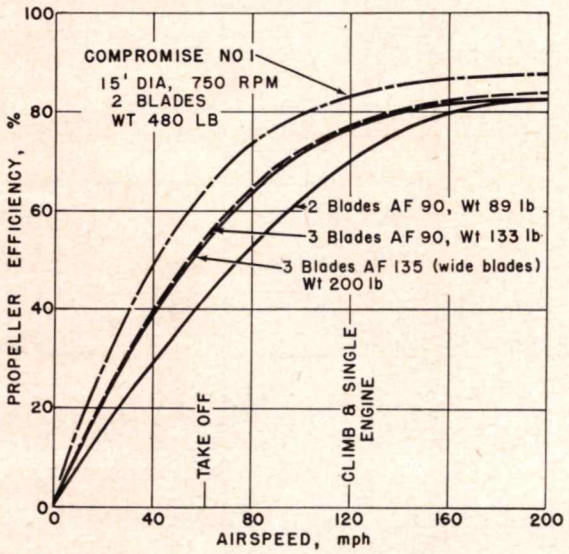


Fig. 5—Compromise Number 3, Propellers limited to 8 feet diameter, 0.8 Mach Number Tip Speed, 2220 rpm, (noise reduced to comfort level)

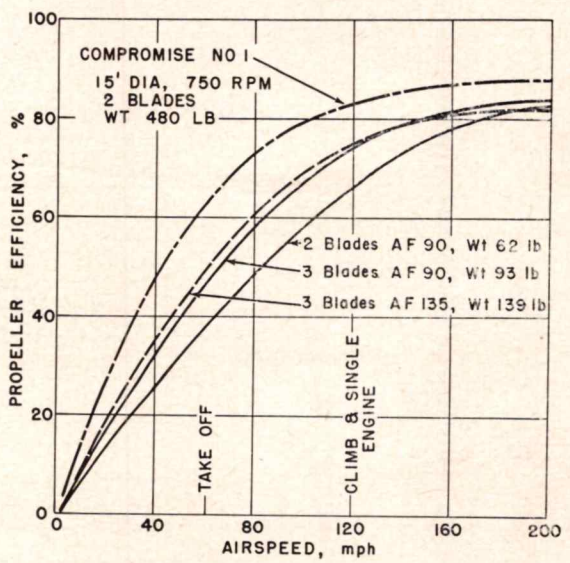


Fig. 6—Compromise Number 4, Propellers limited to 7.1 feet diameter, 0.8 Mach Number Tip Speed, 2220 rpm, (noise reduced to comfort level)

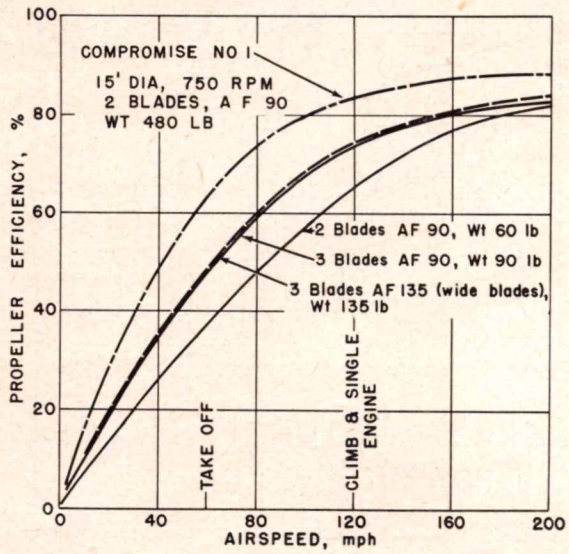


Fig. 7—Compromise Number 5, Direct Drive, 2600 rpm, 0.9 Mach Number Tip Speed, Diameter —6.8 feet

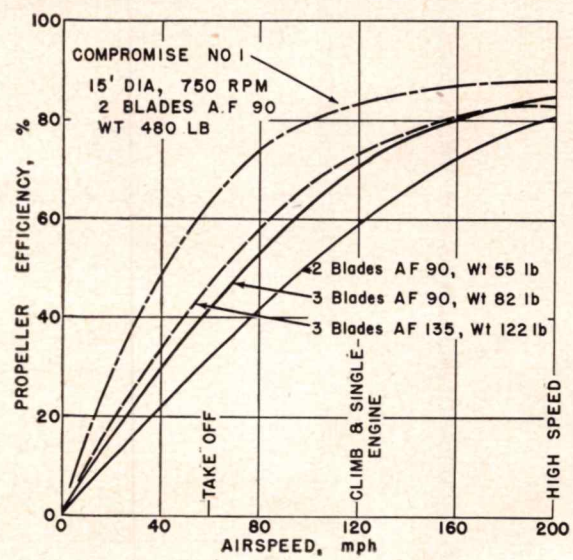


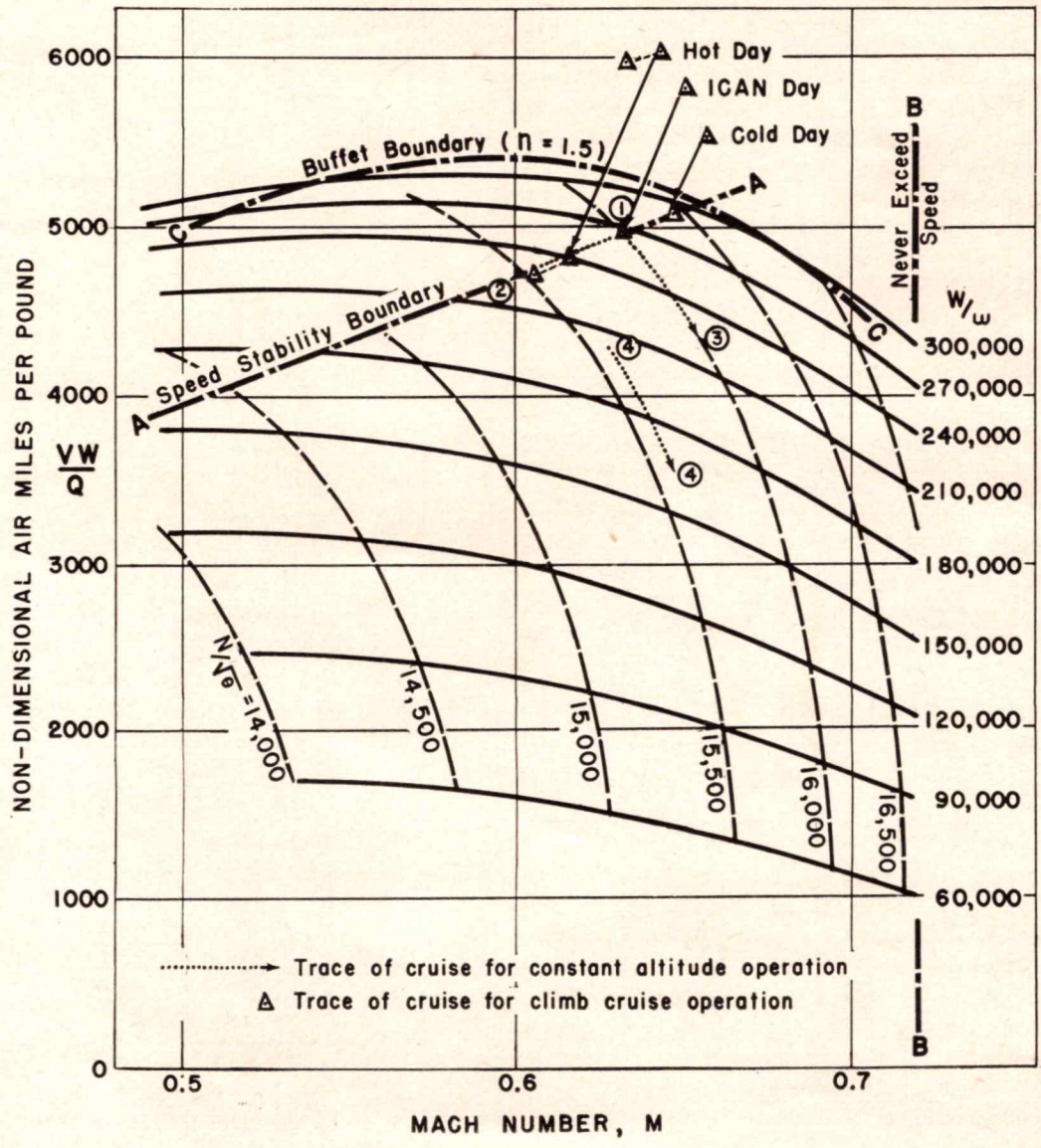
Fig. 8—Compromise Number 6, Direct Drive, 2600 rpm, 0.8 Mach Number Tip Speed, Diameter—6 feet, (noise reduced to comfort level)

CRUISE PERFORMANCE OF JET AIRCRAFT

Theoretical and flight test data are analyzed in graphical form to yield concise and practical cruise control information. Effects of Mach Number on drag are included while effects of ambient air temperature and aircraft weight are taken care of automatically.

By D. C. WHITTLEY
Supervisor, Flight Research and Development
A. V. Roe (Canada) Ltd., Malton, Ontario

Fig. 1—Variation of air miles per pound with speed in "non-dimensional" form.



AIRCRAFT PERFORMANCE at a specified altitude varies according to engine speed, all-up weight, ambient air temperature and humidity. Turbojet aircraft are particularly sensitive to temperature variations; and the advantage of *non-dimensional* presentation of performance, Table 1 and Fig. 1, is that temperature and weight variations are taken care of automatically. The turbojet engine is sensitive to humidity to only a minor degree.

• • Speed Stability Boundary

It is well known that in order to operate a jet aircraft to obtain maximum fuel economy, that is, maximum air miles per pound, it is generally necessary to use the highest engine rpm available for cruise and to fly as high as possible consistent with this rpm. As the aircraft gains altitude, however, it becomes increasingly difficult to maintain steady cruising flight; a decrease in speed or altitude may give only a very small excess of thrust to regain speed or altitude—in other words, the speed stability deteriorates. Before discussing maximum fuel economy, it is therefore necessary to specify the lowest degree of speed stability that can be tolerated according to the type of operation.

Here the problem is concerned with cruising flight for long periods of time at high altitude; still air conditions normally prevail and deviations of speed from conditions of equilibrium are considered arbitrary. The rate of change of acceleration as the aircraft departs from conditions of equilibrium provides a measure of its ability to restore equilibrium. On an analytical basis one notices that this ability is dependent upon the intercept angle of the non-dimensional thrust and drag curves, Fig. 2.

Consider deviation of speed from initial trim speed at constant altitude.

$$(F-D) = \left(\frac{W}{g}\right)a; \qquad (1)$$

Therefore,

$$a = \left(\frac{F-D}{\omega}\right)g \Big/ \left(\frac{W}{\omega}\right), \qquad (2)$$

and, if δ denotes the partial differential-operator, then

$$\frac{\delta a}{\delta M} = \frac{\delta (F-D/\omega)}{\delta M}\,\frac{g}{(W/\omega)} = \frac{g \tan \beta}{(W/\omega)}, \qquad (3)$$

where

$$\tan \beta = \frac{\delta (F-D/\omega)}{\delta M}.$$

The acceleration for a Mach Number deviation of 0.02 from the equilibrium condition is then given by

$$a_{(\Delta M=0.02)} = (0.02 g \tan \beta)/(W/\omega)$$

and this value is plotted against Mach Number with W/ω as parameter, Fig. 3. A value of 0.10 ft/sec^2 is taken here as the minimum acceptable value for satisfactory speed stability characteristics. The physical significance of this quantity is not well defined in practice because of the interchange of altitude with speed which normally occurs in the phugoid motion of an aircraft; it does, however, provide a relative measure of speed stability throughout speed and altitude ranges in which the aircraft will operate. The variation of Mach Number and $N/\sqrt{\theta}$ with W/ω for constant speed stability can now be determined and this variation is superimposed on Fig. 1 to give flight boundary A-A. Flight above this boundary of minimum acceleration is considered unsatisfactory from the point of view of speed stability.

• • Mach Number Limitations

The second boundary is provided by the limiting Mach Number characteristics of the aircraft which in the case of a civil transport would correspond to the *never exceed speed*. This takes the form of a vertical line on the diagram, such as B-B, and operation to the right of this boundary is considered unsatisfactory, Fig. 1.

A third boundary is provided by the buffet limitations of the aircraft. Buffet lift coefficient is a func-

Symbols

a = longitudinal acceleration, ft/sec^2
β = intercept angle between thrust and drag curves, deg
C_L = lift coefficient
D = aircraft drag, lb
F = engine thrust, lb
ΔF = thrust increment, lb
g = acceleration due to gravity, ft/sec^2
γ = ratio of specific heats for air = c_p/c_v
M = Mach Number
n = normal load factor
N = engine speed, rpm
P_a = ambient pressure, lb/in.^{2}
P_s = standard sea level pressure = 14.7 lb/in.^{2}
Q = fuel consumption, lb/hr
S = wing area, ft^2
Θ = T_a/T_s
T_a = ambient temperature, °K
T_s = standard sea level temperature = 288 °K
V = aircraft speed, mi/hr
V_c = rate of climb, ft/min
V_g = ground speed, mi/hr
V_w = wind speed, mi/hr
W = aircraft weight, lb
ω = P_a/P_s

Table 1—Non-Dimensional Forms of Performance Variables

Variable	Unit	Symbol	Non-Dimensional Form
Aircraft Speed *	mi/hr	V	$V\sqrt{\Theta}$
Aircraft Weight	lb	W	W/ω
Aircraft Drag	lb	D	D/ω
Engine Speed	rpm	N	$N/\sqrt{\Theta}$
Engine Thrust	lb	F	F/ω
Air Miles/Pound	mi/lb	V/Q	$V\omega/Q$

$\Theta = T_a/T_s$, $\omega = P_a/P_s$

* It can be shown that $V/\sqrt{\Theta} = 761M$ and since Mach Number has more popular significance, M replaces $V/\sqrt{\Theta}$ as the non-dimensional speed parameter.

tion of Mach Number and a typical variation is shown in Fig. 4. It is desirable to maintain a reasonable margin between flight conditions and the buffet. The load factor available without buffet, denoted by n, is a measure of the ability of the aircraft to turn or withstand gusty air conditions without buffets. Now,

$$n = C_{L\ buffet}/C_{L\ cruise}$$

and

$$\frac{W/\omega}{\gamma P_s S M^2/2} = C_{L\ cruise}. \qquad (4)$$

The minimum allowable value of n would again depend on the type of operation whether military or civil, but once decided the relation between (W/ω) and M is given by Equation 4 and the third boundary C-C can be superimposed on Fig. 1. In this example the value of n was taken as 1.5. Flight above this boundary does not provide sufficient buffet margin and is again considered unsatisfactory.

Three boundaries have now been established on the fuel consumption diagram, and according to the proposed operational rules, cruising flight must be maintained within these bounds.

From Fig. 1 it is true that at a given value of W/ω, maximum air miles per pound is achieved at the highest value of VW/Q allowable, that is, at the intersection of the line of constant W/ω with the boundary A-A. Maximum economy is therefore always achieved by flight somewhere along the boundary A-A.

For civil aircraft with medium thrust-to-weight ratio, engine power provides a ceiling limitation. Maximum air miles per pound is obtained by flight along A-A at a value of W/ω as high as can be achieved at cruising rpm. In practice this represents a climbing cruise at constant rpm (maximum consistent with a reasonable overhaul lift). The pilot flies the aircraft by maintaining a given Mach Number, the value of which varies with (W/ω). This variation is automatically represented to the pilot by a cruise control indicator. The aircraft will execute a gradual climb determined by the rate at which fuel is consumed and the variation of ambient temperature. For the theoretical case in the tropopause where the ambient air temperature remains constant, $N/\sqrt{\theta}$ also remains constant and the flight path is represented by a single point on the boundary line A-A such as point *1* shown on Fig. 1.

An interesting point arises with regard to the transition from climbing flight to cruising flight. Climbing rpm will probably be greater than cruising rpm and the pilot is required to determine the altitude at which he should reduce rpm and commence to cruise. This altitude depends upon the aircraft weight at altitude and corresponding outside air temperature, neither of which will the pilot know accurately before take-off. This problem is resolved quite easily in terms of rate of climb when one considers the non-dimensional thrust and drag curves. The conditions prevailing at this point of transition are represented in Fig. 5 (where β is minimum acceptable value). At this point the available thrust for climb $(\Delta F/\omega)$ and therefore the rate of climb $V_C/\sqrt{\theta}$ can be considered as made up of two parts, one a function of β and the other a function of $\Delta N/\sqrt{\theta}$, where ΔN represents the increment in climbing rpm over cruising rpm. The altitude for changeover from climb to cruise therefore corresponds approximately to constant rate of climb for all values of weight and outside air temperature since both ΔN and β are specified. The aircraft will naturally seek its correct altitude once the cruise procedure is adopted and a small deviation in the transition point is of little importance. The pilot is therefore instructed to climb until rate of climb falls to some specified constant value (approximately 300 feet per minute) and then throttle back and commence to cruise in the manner described.

For high powered military aircraft exceptions to the above procedure may occur. Owing to the increase

Fig. 2—Variation of thrust and drag with speed in "non-dimensional" form.

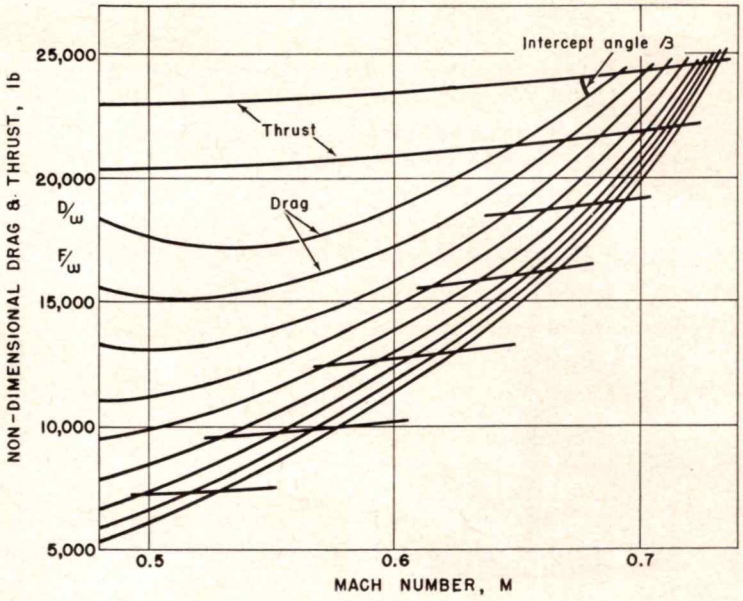


Fig. 3—Acceleration characteristics provide speed stability boundary.

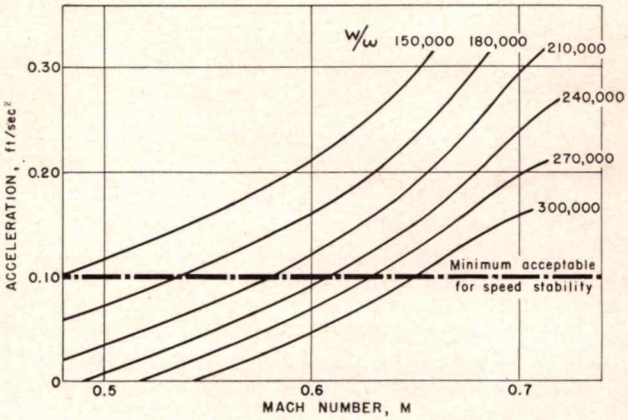


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Table 2—Effect of Cruise Technique on Payload for a 1000 Mile Trip

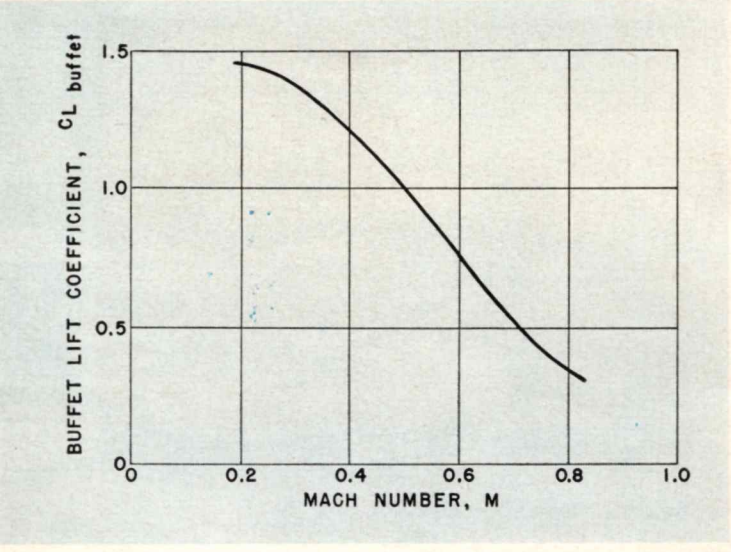
Aircraft Weights and Reserve Allowances

Loaded weight	65,000 lb
Operational weight empty	33,500 lb
Fuel reserve	7,000 lb
Take-off and taxi allowance	500 lb fuel and 6 minutes
Maneuver and taxi to ramp	750 lb fuel and 9 minutes
Maximum engine speed for cruise	13,900 rpm

Code No.	Cruise Technique	Temperature Conditions	Cruising Altitude (ft) Start	Cruising Altitude (ft) Finish	Cruise Speed (mi/hr)	Block Speed (mi/hr)	Fuel Load (lb)	Payload (lb)
1	Climb Cruise	ICAN	36,000	40,000	417	344	21,400	10,100
2	Constant Altitude, Reduce rpm	ICAN	36,000	36,000	406	339	21,665	9835
3	Constant Altitude, Constant rpm	ICAN	36,000	36,000	425	349	21,915	9535
4	Constant Altitude, Constant rpm	ICAN	30,000	30,000	432	363	23,600	7900

in drag at high values of Mach Number and lift coefficient, the maximum value of air miles per pound may occur at a specific value of W/ω, that is, the power available may allow the aircraft to operate at values of W/ω higher than that at which maximum economy would occur; alternatively progress along the line A-A may be halted by the buffet limitation C-C. Either case requires reduction of the engine rpm below maximum continuous value and flight takes place at a single point on the diagram, Fig. 1. The reduction of rpm below the maximum cruising value introduces another variable to the cruise regime and slightly complicates the cruise procedure from an operation viewpoint. The transition from climb to cruise takes place when W/ω reaches the optimum value.

Fig. 4—Variation of buffet lift coefficient with Mach Number provides buffet boundary limitation.



● ● Constant Altitude with Best Fuel Economy

In order to conform to a traffic pattern or to execute a military mission it may be necessary to fly at constant specified altitude. Best economy under this restriction is obtained by climbing the aircraft to the specified altitude and maintaining speed corresponding to the flight boundary A-A. This form of cruise control requires frequent adjustment to rpm as the weight decreases. Once again the variation of Mach Number with (W/ω) according to the flight boundary A-A is automatically represented to the pilot by a cruise control indicator. Cruising flight starts at point *1* on the diagram and ends at point *2*.

● ● Constant Altitude with Constant Rpm

Altitude is specified and standard temperature remains constant. Cruise proceeds along a line of con-

Continued on page 46

Table 3—Effect of Variation of Ambient Air Temperature on Payload for a 1000 Mile Trip

Code No.	Cruise Technique	Temperature Conditions	Cruising Altitude (ft) Start	Cruising Altitude (ft) Finish	Cruise Speed (mi/hr)	Block Speed (mi/hr)	Fuel Load (lb)	Payload (lb)
A	Climb Cruise	Cold Day [1]	37,500	41,500	417	346	20,795	10,705
B	Climb Cruise	ICAN Day [2]	36,000	40,000	417	344	21,400	10,100
C	Climb Cruise	Hot Day [3]	32,000	38,000	417	347	21,870	9630

[1] Cold Day: 5°C at sea-level and 10°C colder than ICAN throughout altitude range.
[2] ICAN Day: 15°C at sea-level.
[3] Hot Day: 25°C at sea-level and 10°C warmer than ICAN throughout altitude range.

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TYPE R-149

EEMCO's unique Type R-149 linear actuator is entirely self-contained; the motor, clutch, planetary reduction gear and limit switch are all enclosed within the smaller inner cylinder. Type R-149 has an unusually long stroke of 9.625″ at .3″ per second under a normal load of 4000 lbs. on a 28 volt DC system. Maximum operating load is 8000 lbs., maximum static load, 15,000 lbs. EEMCO's compact Type R-149 has adjustable load limit switches, non-jamming end stops, and a motor that shuts off automatically when end stops are reached, or load exceeds a pre-set limit. Weight is 10 lbs., 5 oz.

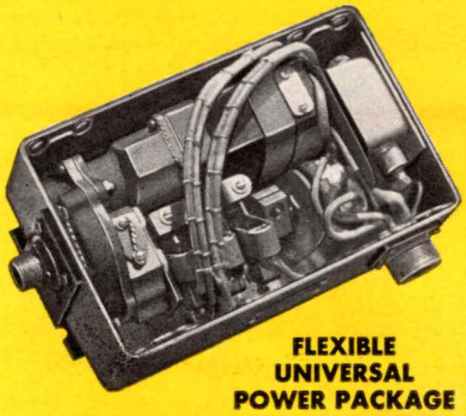
Need Special LINEAR ACTUATORS?

EEMCO can save you valuable development time and expense and speed the delivery of actuators by altering one of its many tested and proven linear models to fit your specific need.

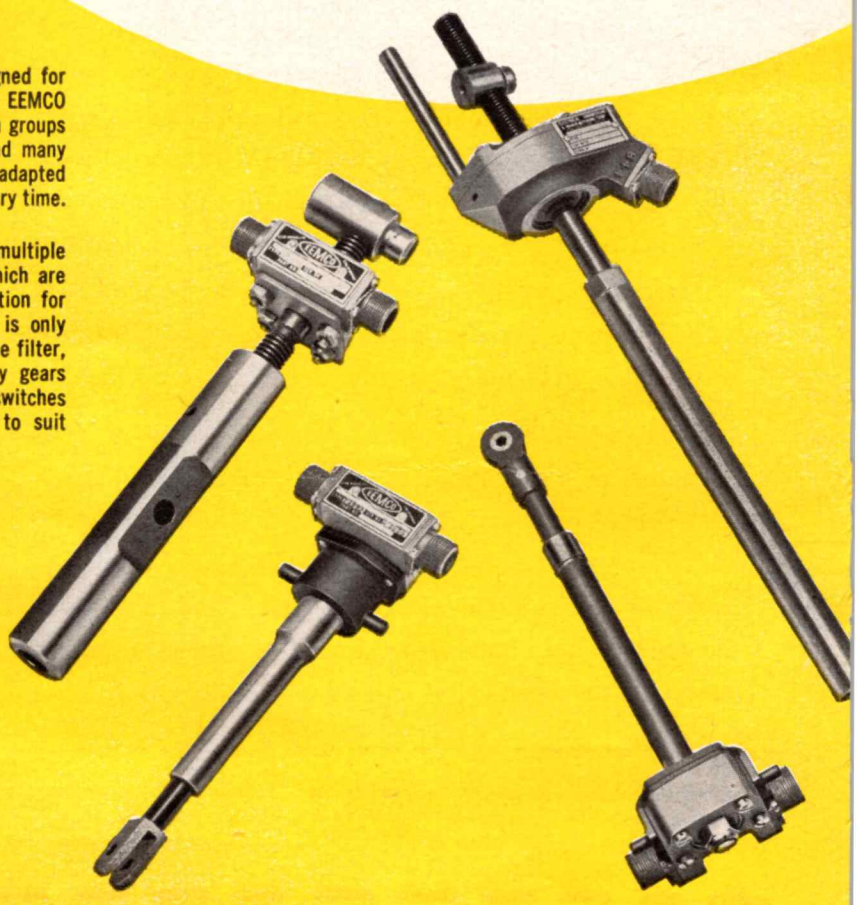
Shown here are a few of many EEMCO self-powered and remote-controlled mechanical linear actuators that have been designed, developed, tested and produced for various air frame manufacturers. There is a definite possibility that one of the actuators illustrated (or others not shown) can be adapted to <u>your</u> specific need as to load, length of stroke, rate of travel, or other characteristic.

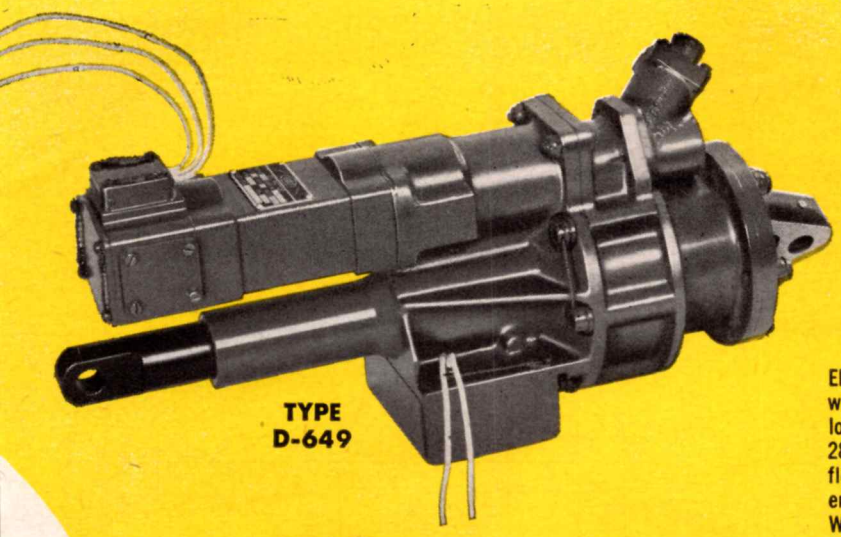
Illustrated at right is a group of EEMCO actuators designed for aileron, elevator and trim tab controls. Powered by the EEMCO Universal Power Package they can be operated singly or in groups to actuate systems — a cowl flap for example. These and many other custom designed EEMCO linear actuators can be adapted for specific purposes with a minimum of expense and delivery time.

EEMCO's flexible Universal Power Package drives single or multiple screw jack actuators, either rotary or linear (some of which are illustrated at right), with direct or flexible shaft connection for remote operation. This compact 3⅜ lb. power package is only 7⅛″ x 4 7/16″ x 2¾″ in size yet contains motor, radio noise filter, magnetic clutch and brake, reduction gear and auxiliary gears operating adjustable limit switches to control travel, light switches and position indicator. Specifications can be changed to suit special requirements.



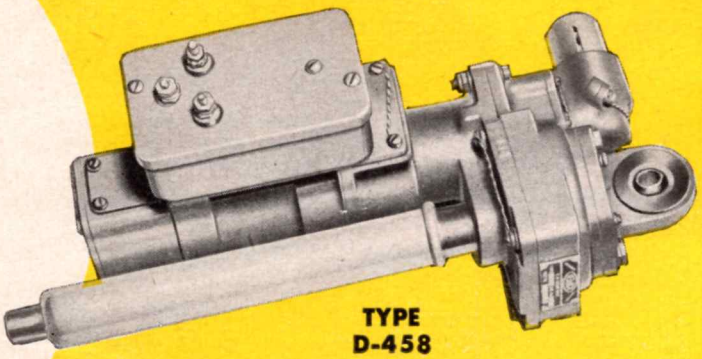
FLEXIBLE UNIVERSAL POWER PACKAGE





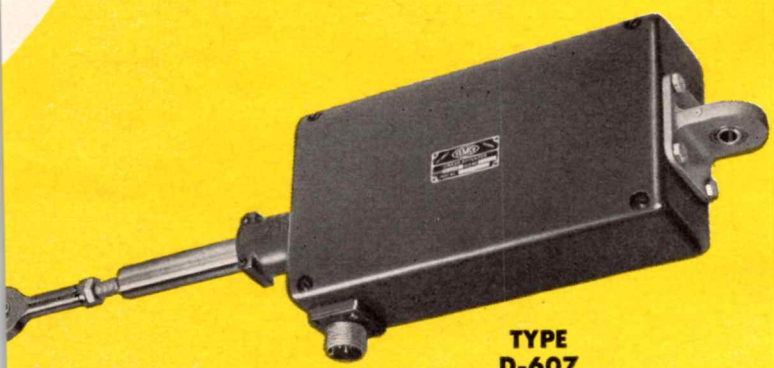
TYPE
D-649

EEMCO's Type D-649 linear actuator weighs 13.75 lbs., and operates with a stroke of 3 5/16" at .55 inch per second under a working load of 3400 lbs. normal tension and 8200 lbs. peak tension on a 28 volt DC system. Maximum static load is 18,750 lbs. It has a flexible shaft drive take-off, load limit switches, non-jamming end stops and a retraction stop that adjusts to within ¼ inch. With minimum expense and delivery time EEMCO's Type D-649 can be supplied for various loads, lengths of stroke, rates of travel and other characteristics.



TYPE
D-458

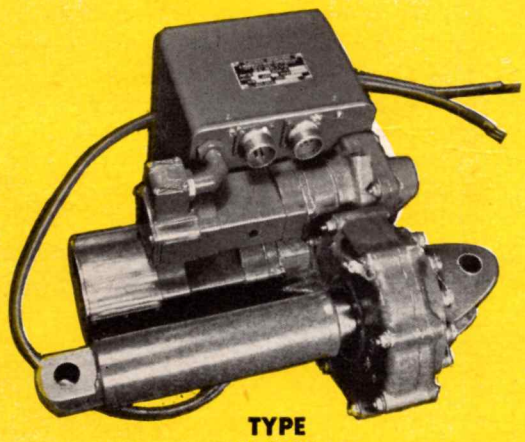
EEMCO's Type D-458 linear actuator for jet wing flaps weighs 8 lbs., 3 oz., has a stroke of 5.14" at .4" per second on 28 volt DC system under a normal load of 3000 lbs. Ultimate static load is 10,000 lbs. compression in fully extended position. Type D-458 has non-jamming end stops, provision for power take-off or hand drive (right angle) and radio noise filter. Load, stroke, rate of travel and other features of EEMCO's Type D-458 can be changed to suit specific needs in a minimum of time.



TYPE
D-607

EEMCO's Type D-607 is a door actuator for transport aircraft which weighs 4.5 lbs. and has a stroke of 6.25 inches. Linear rate of travel is .33" per second at the rated load of 450 lbs. compression. Ultimate static tension load is 7000 lbs. EEMCO's Type D-607 has non-jamming end stops, adjustable travel-limit switches, radio noise filter and operates on a 28 volt DC system.

EEMCO's Type R-129 is a stabilizer actuator for large jet fighters. It is a complete actuator assembly incorporating two motors, 1/10 hp and 3.3 hp, operating through gear reductions to give a drive rate of 6/100" per second and 7/10" per second respectively to the screw jack. Normal operating load is 11,000 lbs.; static load is 80,000 lbs. The small motor operates almost continuously with automatic pilot, while the larger motor provides for manual pilot control at a higher rate of maneuvering. Type R-129 operates on a 28 volt DC system, has overload and limit switches, radio noise filter, position indicator, non-jamming stops. Weight, 45 lbs.



TYPE
R-129

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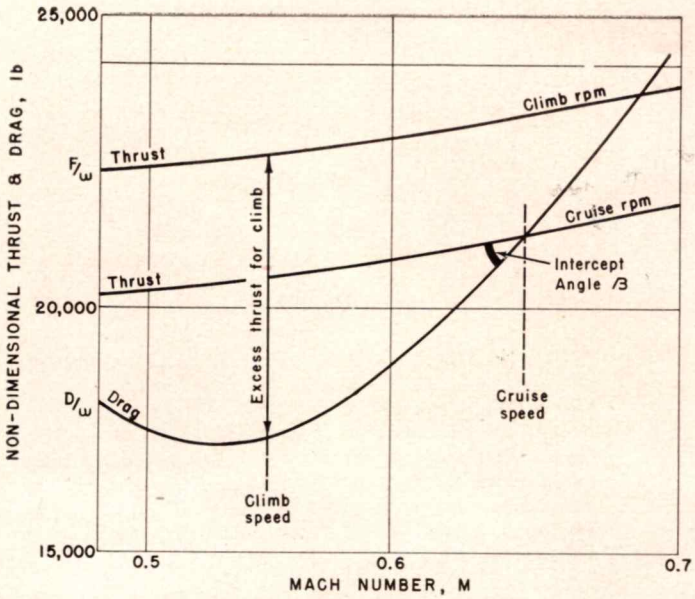


Fig. 5—Conditions prevailing at point of transition from climb to cruise.

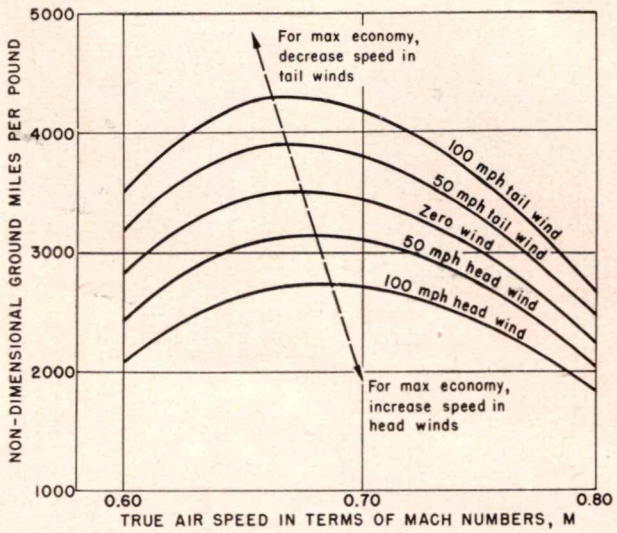


Fig. 6—Variation of ground miles per pound with speed at cruising altitude showing effect of wind velocity on speed for peak miles per pound.

stant $N/\sqrt{\theta}$ and if limiting Mach Number is reached, rpm is gradually reduced to hold this limiting speed. Cruising flight starts at point *1* on the diagram and ends at point *3*. A similar flight at lower cruising altitude would be represented by the line *4—4* in Fig. 1.

It has already been noted that the variation of Mach Number with (W/ω) for best economy is independent of variation in ambient temperature. True speed and fuel consumed do vary however and these changes are considered relative to ICAN (*International Convention on Air Navigation*) standard conditions.

● ● Fuel Consumed

Consider conditions, as for transport aircraft, where maximum continuous cruising rpm form a ceiling limitation. For sub-standard temperatures $\sqrt{\theta}$ will be lower than normal.

Since N is constant and equal to the maximum continuous value, $N/\sqrt{\theta}$ will be higher than normal and flight will be possible at a higher value of W/ω than on a standard day. If the same aircraft weight is considered, then flight at higher altitude is called for, with consequent improvement in air miles per pound. On a *cold* day the climb cruise takes place at higher altitudes and on a *hot* day at lower altitudes than on a standard day.

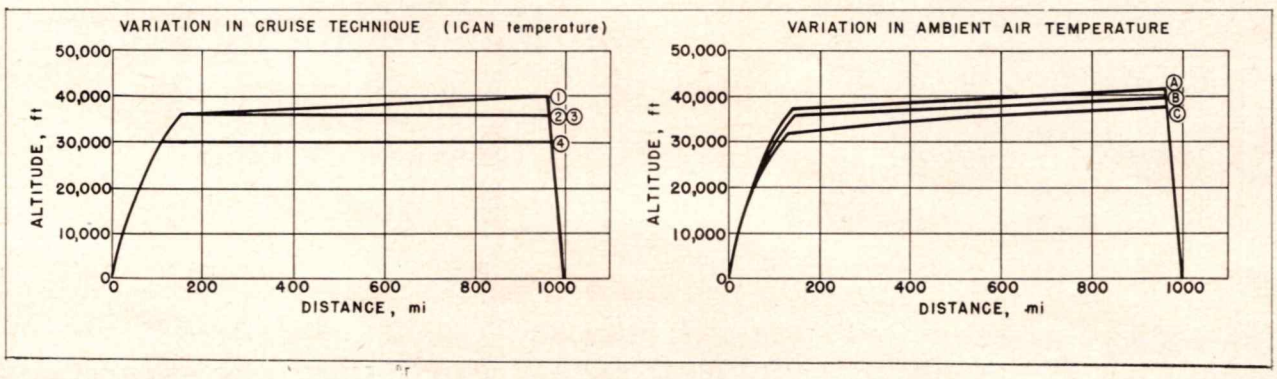
Consider conditions for military aircraft where maximum economy may occur at constant W/ω. Cruising flight takes place at a single point on Fig. 1 and values of VW/Q, $N/\sqrt{\theta}$, W/ω, and M all remain constant. At a given weight the constant value of W/ω defines ω, and therefore also altitude, independently of temperature conditions. Similarly, air miles per pound (V/Q) is independent of temperature whereas rpm is adjusted according to temperature to maintain $N/\sqrt{\theta}$ constant. An aircraft in this class therefore exhibits no variation of cruising air miles per pound on off-standard days when operating to give maximum economy.

● ● True Air Speed

Again considering conditions for transport aircraft, one notes that on a cold day the Mach Number is slightly increased; the lower ambient temperature causes the speed of sound to be less than on a standard day and the resulting true speed therefore changes very little. Considering conditions for military aircraft, however, one notes that Mach Number remains constant and the airspeed varies as the speed of sound,

Continued on page 48

Fig. 7—Altitude distance patterns for a 1000 mile trip.



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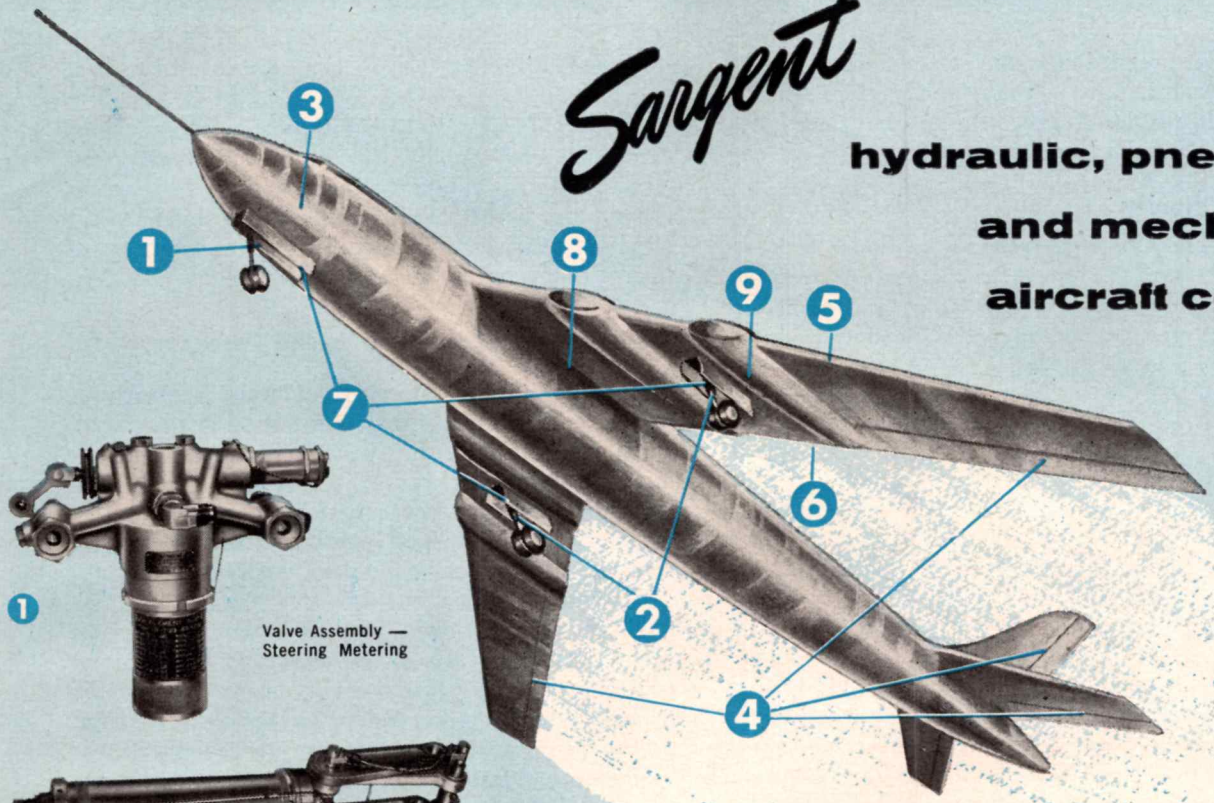
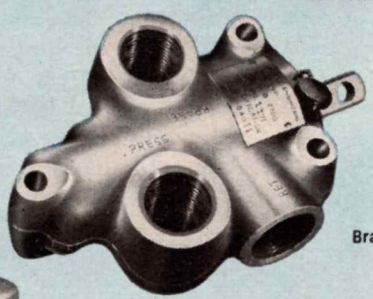
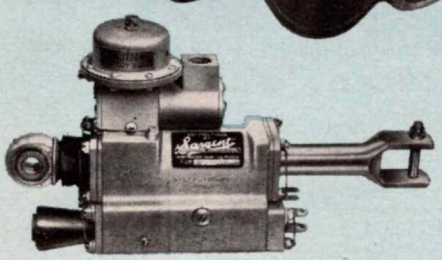


1 Valve Assembly — Steering Metering

2 Main Landing Gear Retractor



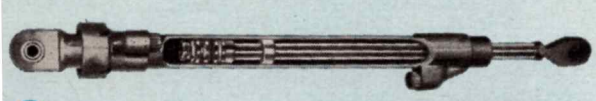
3 Brake Valves



4 Power control units for rudder, elevators and flaperons

5 Slat Actuating Cylinder

6 Gear Box Assembly — Outer Wing Flap Drive



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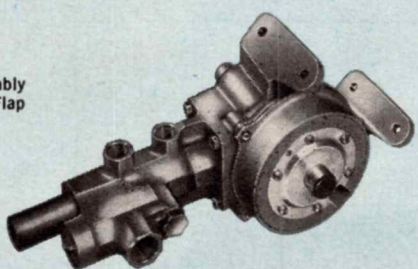
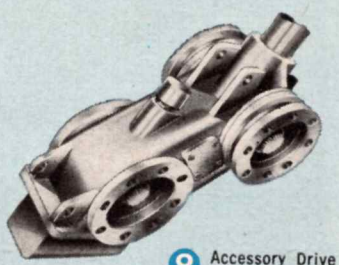


8 Spoiler Valve



9 Accessory Drive Power Take-off

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—U. S. Supreme Court

that is, in direct proportion to the square root of the absolute temperature. On a cold day therefore true air speed is slightly lower and on a hot day slightly higher than the standard value.

• • Wind Velocity

To see the effect of wind velocity on cruise technique, it is necessary to know the relationship between air miles per pound and ground miles per pound. Let V_g denote ground speed and V_w denote wind speed. Then

$$V_g = V + V_w, \tag{5}$$

$$\frac{V_g}{V} = 1 + \frac{V_w}{V}, \tag{6}$$

and

$$\frac{V_g W}{Q} = \frac{V W}{Q}\frac{V_g}{V} = \frac{V W}{Q}\left(1+\frac{V_w}{V}\right) \tag{7}$$

Consider again conditions for military aircraft where W/ω remains constant. Curves can now be produced of non-dimensional ground-miles-per-pound $(V_g W/Q)$ versus Mach Number for various wind velocities under standard temperature conditions, Fig. 6. Tail winds move the peak air-miles-per-pound to lower values and head winds to higher values of Mach Number. Cruising speed will therefore be adjusted accordingly, if absolute maximum economy is desired under non-zero wind conditions.

For aircraft with speed stability characteristics that do not permit operation at the peak value no advantage can be obtained by adjusting speed—that is, of course, assuming one abides by the speed stability boundary limitations. For certain aircraft that are able to fly at this peak value for zero wind, flight at lower speeds with a tail wind may still be unsatisfactory, whereas flight at higher speeds with a head wind would give improved speed stability; the advantage of speed adjustment would then be restricted to head winds only.

Civil type aircraft with low power rating exhibit marginal speed stability at peak air miles per pound. High powered military aircraft more often exhibit satisfactory speed stability at the peak; this is associated with the sharp increase in drag and consequent increase in intercept angle β at high speeds.

• • Route Analysis for a Jet Transport

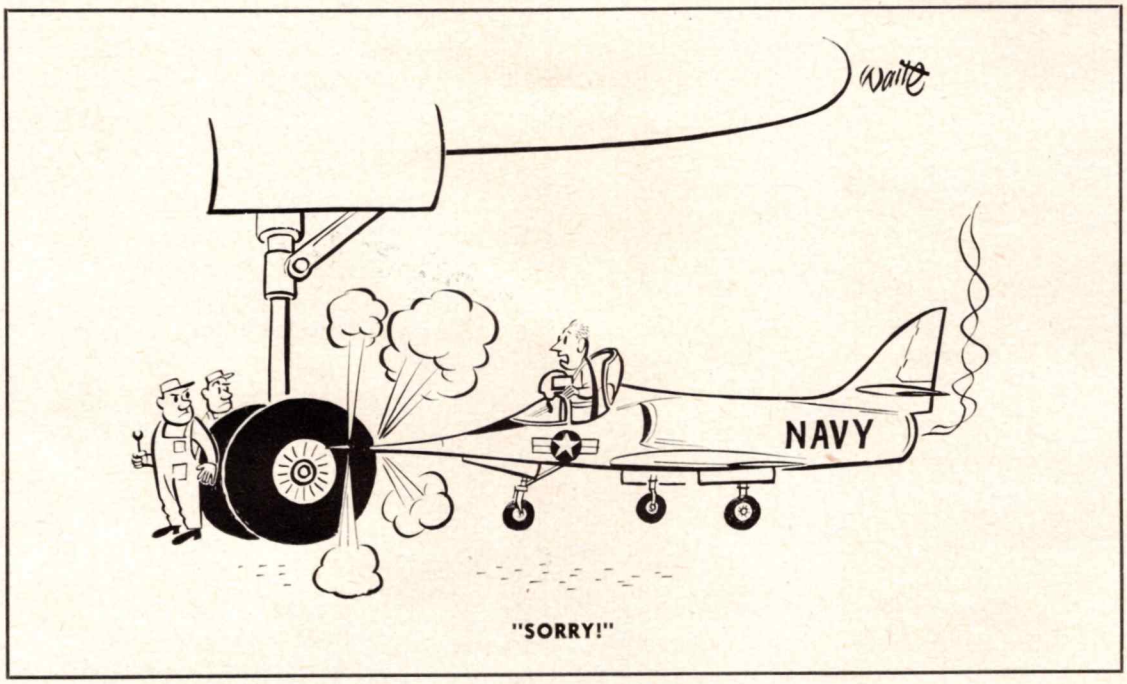
In order to illustrate effect of cruise control techniques and variation in ambient air temperature, calculations were made for a 1000 mile trip taken by a theoretical medium range jet transport. Fuel consumption and level speed performance are given by Fig. 1. Take-off weight is assumed constant and the variation in payload indicates the effect of cruise technique.

Table 2 indicates the effect of variation in cruise technique, and Table 3 the effect of variations in ambient air temperature. Fig. 7 shows altitude distances pattern for the various techniques considered.

The climb cruise technique gives more payload than operation at constant altitude and constant rpm. Operation at 30,000 feet instead of 36,000 reduces the payload by 1635 pounds but increases the block speed from 349 miles per hour to 363 miles per hour. It is of interest to note that on a *hot* day the climb cruise is begun below the tropopause and the aircraft path is slightly steeper than for the subsequent operation above the tropopause; during climb cruise below the tropopause the operational point on Fig. 1 moves slowly along boundary A-A until the ambient temperature is stabilized. END

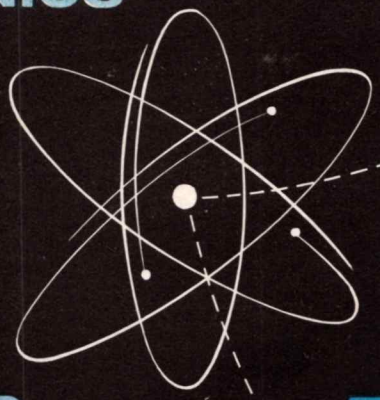
Reference

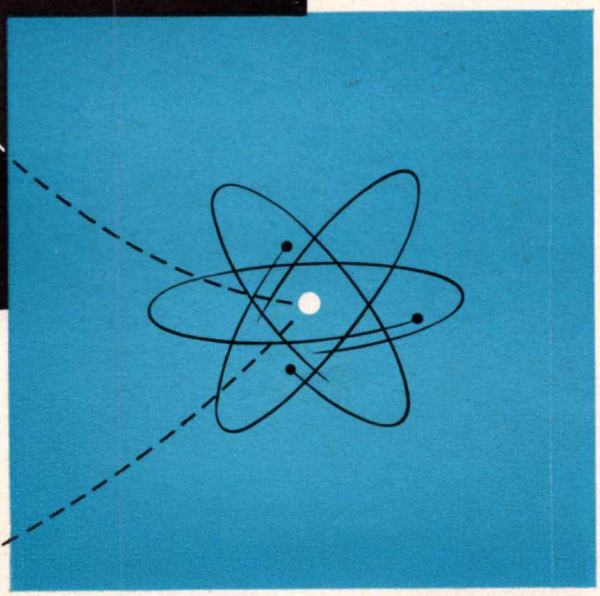
A Non-Dimensional Graphical Method of Turbojet Performance Reduction — Performance Data Sheet RJ1/3, The Royal Aeronautical Society, London.



"SORRY!"

BUILDING ELECTRONICS INTO SMALLER SMALLER SMALLER PACKAGES





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New Navy Cougars Scramble After Unknowns

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When your Air Defense Filter Center has received two reports, the plane is tracked on the plotting table. The plane and track is then reported to the Air Defense Direction Center.

If the aircraft does not fit into the Direction Center's flight plan information, it becomes an "unknown". Now Navy fighters are also "scrambled" to intercept and identify or destroy.

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Designers and builders also of the supersonic Tiger, the Albatross amphibian, S2F sub-killer, metal boats, and Aerobilt truck bodies.

Grumman

The Navy, as part of the Continental Air Defense Command, sends land-based Cougar I's* and the new Cougar II's to intercept. The Cougar II not only is faster and has longer range than the Cougar I, but can pull a high altitude turn in half the radius. Another example of Grumman planes ready in quantity when needed.

*On April 1, 1954, the Navy proved the speed of Cougar I's by flying three coast to coast in the fastest time yet. The first made it from San Diego to Floyd Bennett Field in 3 hours, 45 minutes, 30 seconds. The other two were less than 2 minutes slower.

In the fabrication of the Beechcraft *Bonanza* a weight saving of 18 pounds and a time saving of two hours has been effected by using hot formed magnesium control surfaces in preference to aluminum surfaces. Forming is done on four basic machine tools.

HOT FORMED MAGNESIUM SKINS
Save Weight and Time

By R. H. OWEN
Manager, Manufacturing Engineering
Beech Aircraft Corporation, Wichita, Kansas

HOT FORMING magnesium at Beech Aircraft is done by hydraulic press, punch press, drop hammer, and power brake. In all cases the tools or materials are electrically heated.

Handling magnesium requires a directed effort to avoid corrosion. The material is received with a light coating of oil that is left on throughout all operations prior to forming. Then just before forming, the material is vapor degreased; after forming, it is immediately re-oiled.

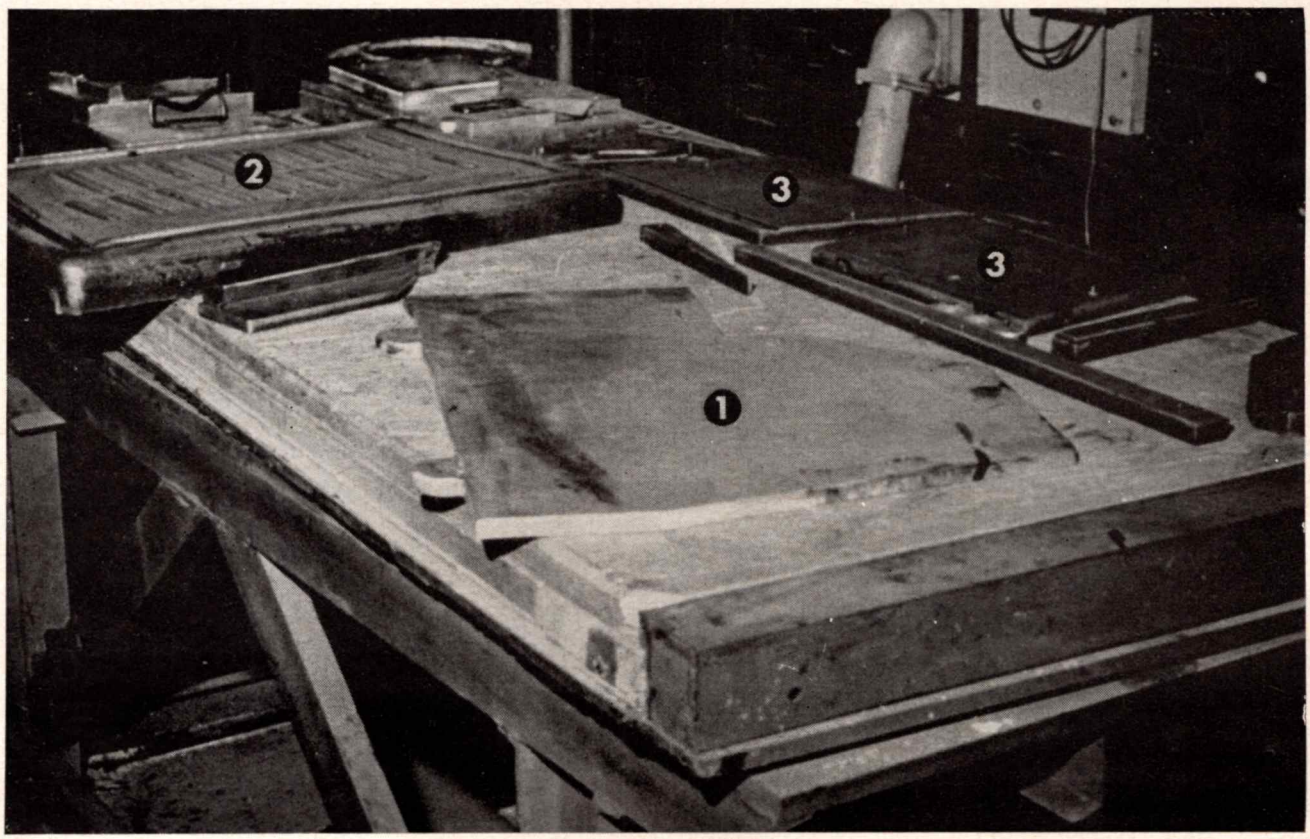
All magnesium sheet received has an acetic-nitrate pickled finish. This finish provides corrosion protection by removing surface impurities, rolled-in mill scale, and iron pick-up from the rolls. With this finish, considerable forming improvements are gained. The etched surface grips the pad and distributes the draw pressures more uniformly. Scrap losses are appreciably reduced.

Sheet, when removed from the crates, is placed on edge on *A* frames and handled in this way throughout the shop. The upper edges are protected from moisture and excessive humidity by waterproof canvas covers.

• • Hydro Forming

The majority of parts are hot formed on the hydraulic press. The rubber pad or *Guerin* process is used. The hydraulic press is employed for forming simple, straight, or flanged patterns, and for producing beads in flat areas. The dies are for the most part made of Kirksite. Since the

Fig. 1—Dies are shown being preheated prior to being used in the hydraulic press. The die in the foreground (1) is of aluminum. The die on the left (2) is of kirksite. Small dies shown (3) are of steel.



Power for Pneumatic Systems *

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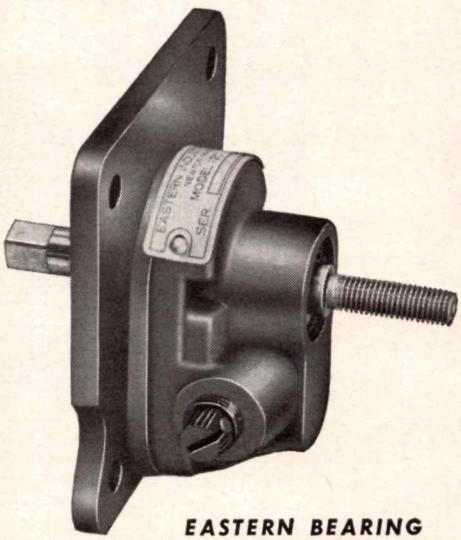
Smaller than a basketball . . . yet packed with power.

with smaller, lighter parts



EASTERN BEARING LUBRICATION PUMP

Small enough to hide in one hand! Only 10 ozs.

The Walter Kidde 4-D Compressor gives 11¼ pounds of pneumatic power in a space 10″ square. This light, small unit is a masterpiece of engineering requiring small components. The Eastern Lubrication Pump has what it takes for this task. A bantam in size and weight . . . a heavyweight in performance.

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Fig. 2—Thermostatically controlled hot plate used as the hydraulic press loading table. The table on which hot plate rests is fed hydraulically to the press on the right. On the side opposite the 2500 ton press is a conventional cold loading table used to alternately run cold formed aluminum parts and hot formed magnesium parts. Over the hot loading table is a hoist supporting a blanket of heat resistant rubber used to prevent sticking of the blanket to the hot dies or parts.

material and the dies are run at the same temperature, the Kirksite dies do not require correction for expansion.

The platen or table is heated by electric strip heaters thermostatically controlled through a range of 250 to 525 degrees Fahrenheit. Temperature depends upon the type of part, size of form block or die, and formability of each particular lot of magnesium sheet. Dies are preheated on a duplicate hydro table in an adjoining shop area, (Fig. 1). Once heated to the required temperature, the dies are placed on the heated hydro loading table as needed, (Fig. 2).

To prevent rubber from sticking to the hot dies, table, or parts, a one inch thick blanket of heat resistant rubber is placed over each table load prior to forming. The rubber blanket found most practical is U. S. Rubber Product Number M8710. This method also allows other loading tables to be operated cold, on a normal basis, with aluminum.

Cut out rubber pads ¼ inch thick called *gates*, are also used as forming accessories for beads. The gate provides additional pressure at an adjoining radius to produce a true flat area on parts without *cans*.

For forming small ribs, spars, and so forth, magnesium material is comparable to 24S-O aluminum and the tools are designed for the same springback and allowances.

Wiper plates are used to fabricate parts that require a draw action. The die and wiper plate are constructed of steel. In this case, the small blank is preheated by placing it on the heated platen while the operator is unloading the part just formed. A very short heat time is required to bring the blank to temperature.

A lubricant, Kendex Number 4280, is used only on the stripper plate block when hydro forming. The lubricant is heated to the melting point, and poured in stick form for easy application. Standard Oil Number LF0604 is also satisfactory. Both lubricants are removed by vapor degreasing in subsequent processing.

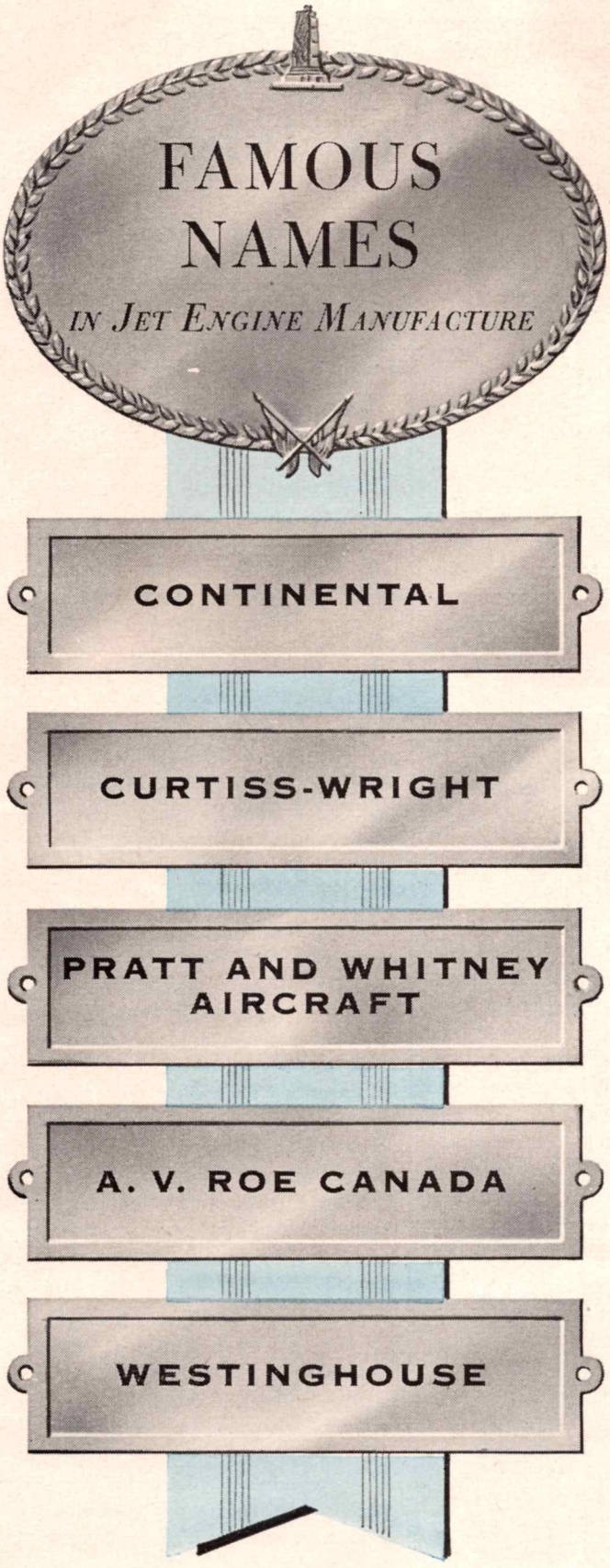
● ● Drop Hammer Forming

Drop hammers are used wherever it is possible to avoid the high cost of punch press tools. Yet drop hammers are often not particularly suitable because of temperature variations during the several strokes necessary to form the part, the temperature required, extreme drawing speeds, and the undesirable working conditions created by the necessity for handling the material at elevated temperature.

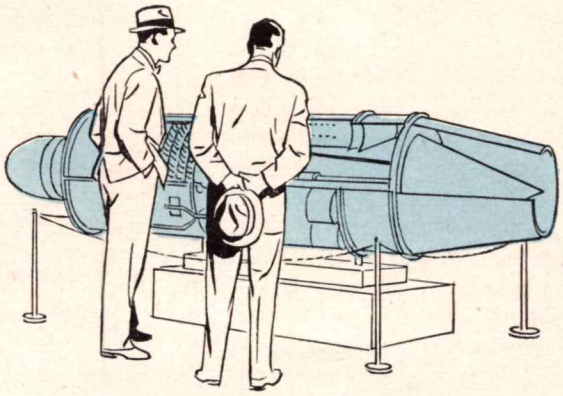
When annealed magnesium sheet is formed at 550 degrees Fahrenheit, its formability equals approximately that of 24S-O aluminum, and the forming is similar to cold forming of aluminum. Temperature variations and extreme speeds of operation make severe drawing in the drop hammer difficult. Shallow draws can be readily accomplished.

Springback of magnesium decreases as the forming temperature is increased toward the allowable limit. At required drop hammer temperatures, springback is at a minimum. Drop hammer tools, both punch and die, are usually made of Kirksite. Dies have been oven heated to 300 degrees Fahrenheit to prevent the heated blank from cooling too rapidly when it comes in contact with the die; this has been done only with parts having critical forms.

Heated parts are rushed immediately to the drop hammer for forming since the heat loss is estimated to be 30 to 45 degrees Fahrenheit in five seconds. Runs have proved successful when using the Standard Oil lubricant. Shallow draw parts are generally run on the hydraulic press where the temperature controls are more consistent. Deep draw parts have been of such dimensions that heated draw dies for the hydraulic



.....all using Bendix ignition equipment!



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We are perhaps even more gratified, however, that our association with famous names in engine manufacturing has extended over many years and has covered a wide diversity of ignition products.

This continuing association with the industry's leaders has been more than a source of pride to us. It has been a challenge that we strive constantly to meet, and we pledge our every resource and facility to continue to merit this acceptance as The Most Trusted Name in Ignition.

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press have been more practical and economical.

● ● Punch Press Forming

Punch presses are used to form those parts that are not adaptable to the hydro press because of the severe depth of the formed sections, the amount of draw, or the quantity of parts required. Forming speed is extremely important, and should give a uniform rate of stretch over the entire formed area. Hydraulic presses, with a ram speed of ten inches per minute or slower, offer the best deep draw forming. Magnesium, of all materials, requires the least deep drawing pressure, but should be completely formed in a single stroke to prevent abnormal grain growth. During reheating, localized over-heating at bend areas will often cause undesirable grain growth.

Material temperatures of 500 to 550 degrees Fahrenheit are essential to obtain the lowest possible yield strength in compression. (Fig. 3). Only those portions of the die actually in contact with the material being formed need be at that temperature. In portions of the draw die where additional stretching is desirable, a lower temperature of 200 to 350 degrees Fahrenheit is maintained by remote heating elements or dual control. Heating is not provided for punches in all cases, as contact with lower section of the draw die is sufficient.

Punch press draw dies are made of cast Acmealloy where possible. Dies made of steel, with sections bolted together, work loose. Thermal expansion (shrinkage) correction must be allowed in the draw die in order that part size tolerances are correct after part has cooled. Springs for draw rings are, of necessity, often replaced because of damage at elevated temperatures. No requirements for draws over approximately one inch presently exist at Beech.

● ● Brake Forming

Magnesium is comparable to 24S-O aluminum, when formed in the power brake, if proper attention is given to minimum bend radii, forming temperature, and the time at rated temperature. At 325 degrees Fahrenheit, hard roll magnesium exhibits better formability than 24S-T3 does at room temperature.

Normal brake dies, inserted in thermostatically controlled heated shoes, are attached to the brake upper ram. Cleaned parts are preheated on the portable hot plate, formed, degreased, and re-oiled. Care must be taken with regard to forming speeds. The brake, in this operation, is considered a fast machine, even though the ram is stopped at the moment of contact with the part prior to forming. Very few parts are brake formed at Beech.

● ● Economy

Magnesium assemblies are considered to be more expensive than aluminum from a material cost standpoint. However, price changes have brought magnesium materials closer to the cost of 24S-O aluminum. In addition, the overall benefits of ease of forming and less handling, as well as the weight benefits, have made magnesium a desirable material to use as skin covers for control surfaces and interior panels within the cockpit. END

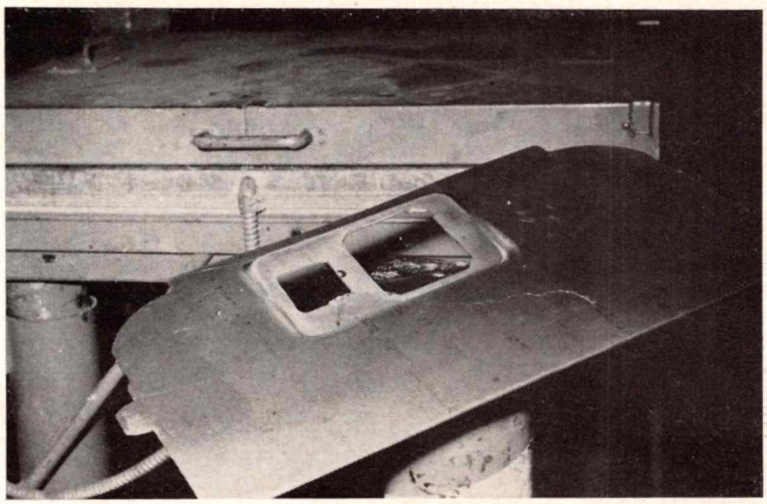

Fig. 3—Punch pressed piece. Background, portable hotplate used for preheating material prior to forming.

Flat Plate TV Tube

First step in a long-range program for simplifying aircraft instruments is the development of a television tube based on human engineering research and employing a flat plate TV tube.

Developed and adapted for Navy use by the electronics division of Willys Motors, it is the first step in a program designed to give an instrument panel consisting of only two basic instruments. These would both be television picture tubes. As envisioned, one instrument would be a semi-circular plate mounted vertically and directly in front of the pilot. Being transparent, it would not interfere with the pilot's vision during contact flight. Altitude, speed, and attitude would be shown on this plate and physical features would be depicted artificially, giving the pilot all he needs to know to fly the aircraft about its three axes: pitch, roll and yaw.

The second instrument would be a round plate mounted just below the first. Broad physical features would be depicted by analogy and the appearance would be somewhat similar to that of a radar map. Other information necessary for navigation or traffic control would also be shown on this instrument. By means of calibrations around the rim the distance to base, fuel remaining and similar information would be shown in a way that makes the information easy to read and assimilate.

The TV tubes will not be used to present an actual picture of what is happening in the vicinity of the aircraft. Rather, they will give an analogy of what he would see if flying by contact, thus giving a more easily understood picture of the visible world than is now presented by dials and pointers of conventional instruments.

Work on the project is being done by the El Segundo Division of Douglas Aircraft Company, and it is expected that the first experimental aircraft using this instrument and control system will be flown around 1958. END

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Write for Descriptive Bulletin 440

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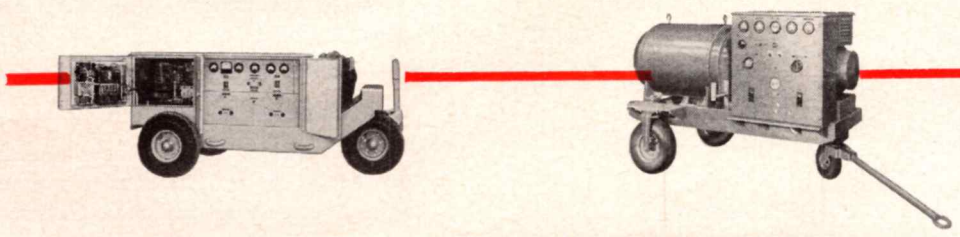

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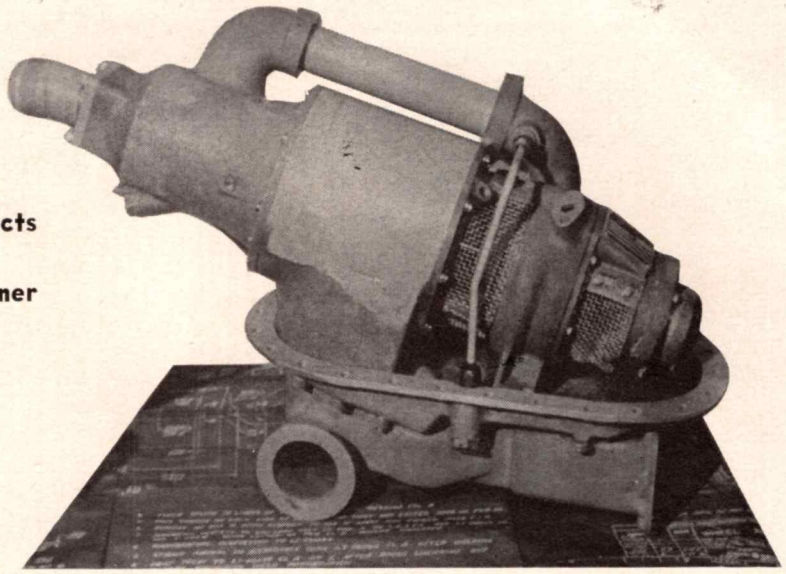
Pump's two stage turbine drive extracts jet engine power only during afterburner operation.



Air Driven AFTERBURNER FUEL PUMP Reduces System Weight

By M. C. TOTH
Supervisor, Application Engineering
Aircraft Accessory Turbine Department
General Electric Company, Lynn, Mass.

A NEW TURBO FUEL PUMP, featuring a combination of high pressure pump, boost pump, and vapor eliminator in one package, provides weight and space saving, and reduces complexity of afterburner fuel system of the North American F-86D *Sabre Jet*. By adopting the new pump (Fig. 1), the airplane has saved twenty-five pounds over the pump originally scheduled for use.

The General Electric turbo pump (above) is a tank mounted, air turbine driven, high pressure, centrifugal type designed for use with turbojet afterburner systems. It can replace systems that involve various combinations of electrical boost pump and afterburner pumps. Basically, the pump (Fig. 4) is a dual rotor unit, with contra-rotating turbine wheels. The first stage rotor drives the high pressure pumping element, and the second stage rotor drives the low speed boost pump. The second stage rotor operates at relatively low speeds and at low power. The conventional row of stator blades between the two wheels has been eliminated. The energy leaving the first stage wheel is utilized directly by the second stage wheel.

The unit was designed for gasoline, MIL-F-5572, 86 gallons per minute fuel flow, and 600 pounds per square inch pressure rise.

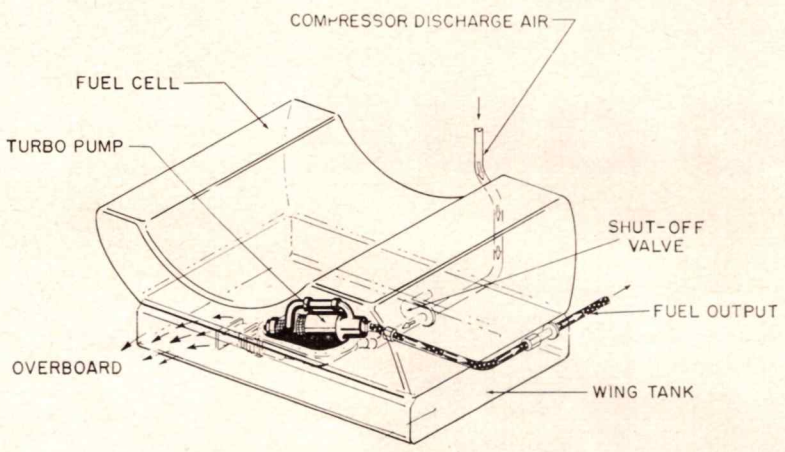


Fig. 1—Turbo fuel pump installed in F-89D afterburner fuel system.

● ● How the Unit Operates

Air to drive the pump is supplied by the jet engine compressor, and is directed by ducting to the axial flow dual rotor turbines. These turbines drive the two separate pumping elements. The exhaust air of the turbine drive assembly is discharged overboard to ambient pressure.

Tank fuel enters the double inlet centrifugal impeller of the booster pump. At this point, the fuel is cleared of entrained air and fuel vapor. Vapor free fuel leaves the low pressure element at a boost pressure above the vapor pressure of the fuel, and is ducted to the inlet of the high pressure impeller. The high pressure centrifugal type pumping element raises the fuel to the final discharge pressure.

● ● Overspeed Control

The turbines of the turbo pump are designed to limit rpm to a safe value by using aerodynamic features

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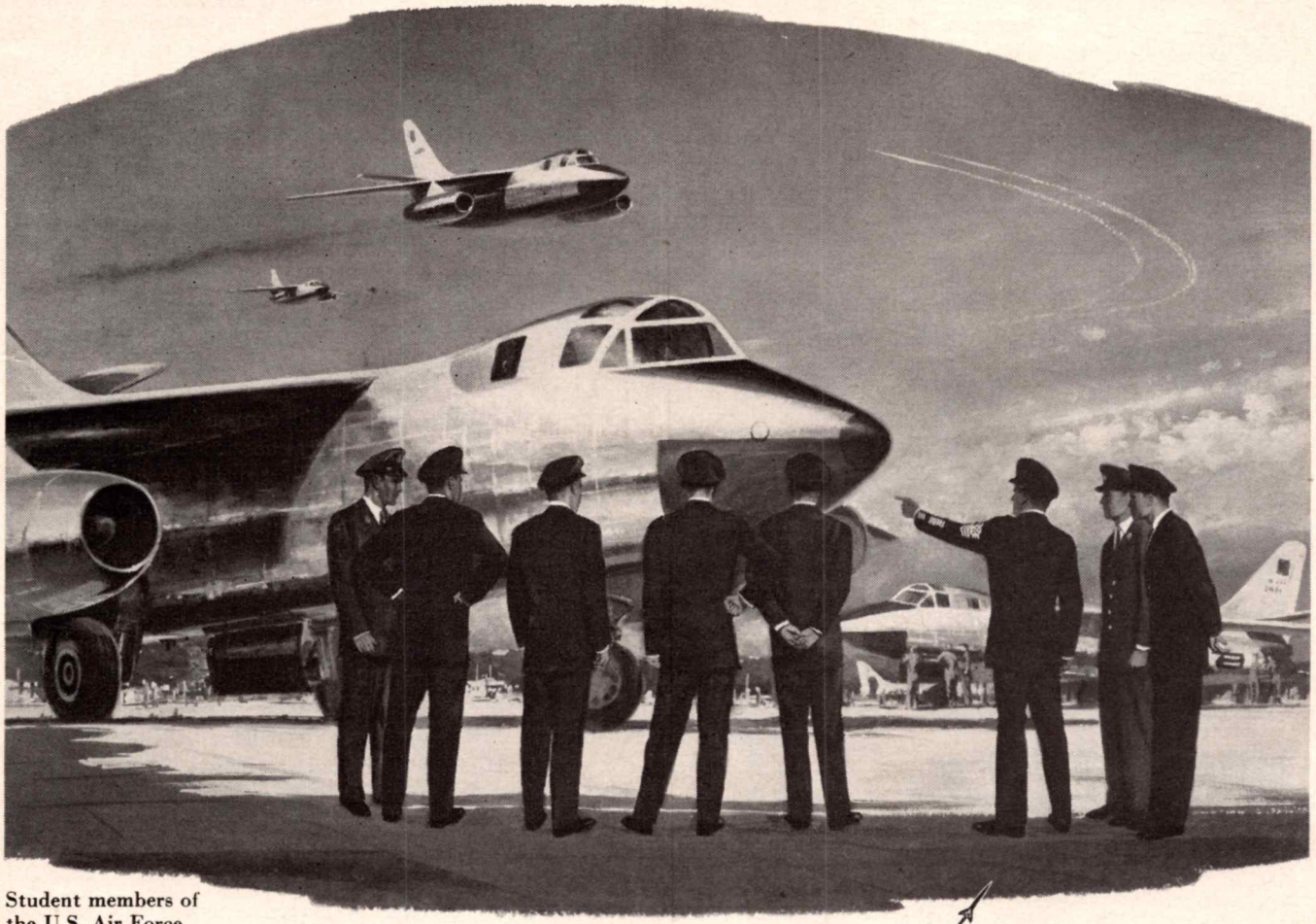
As a designer and builder of modern aircraft, Douglas is in a position to judge the skills developed by Air Force training. They couldn't be higher.



Student members of the U.S. Air Force study a Douglas RB-66

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designed into the flow path; the need for external gadgets is therefore eliminated. Basically, this is accomplished by mounting reversing vanes (Fig. 2) on the outer periphery of the main buckets. During overspeed operation, the inlet conditions to the main bucket sections result in a spoiling action in the main bucket passage; thus choke is induced and flow is diverted to the reversing vanes mounted on the outer periphery. Useful work output of the wheel is therefore expended on this secondary flow as it passes through this stage. For normal operating conditions, the turbine is designed so that this effect is minimized, Fig. 3. The air leaving the overspeed vanes of the first stage wheel impinges upon the blade sections of the second stage wheel such that a retarding force is also applied to the second stage wheel.

• • Vapor Elimination Principle

The liquid-vapor mixture enters both ends of the pumping chamber and is forced toward the periphery of the boost pump impeller by the centrifugal action of the impeller rotation. The passages of the impeller are proportioned to separate the vapor from the liquid and deliver the liquid to the chamber at the impeller periphery. This clear liquid then flows continuously from the pump discharge port under steady pressure.

The vapor bubbles are directed through the impeller passages to annular vapor collecting grooves near the entrances of the pumping chamber. The vapor pump withdraws the vapor from the annular groove by maintaining a continuous suction on the connecting passages. The vapor is then compressed sufficiently to discharge back into the fuel tank.

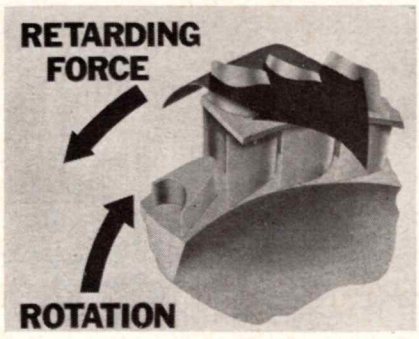


Fig. 2—Principle of overspeed control.

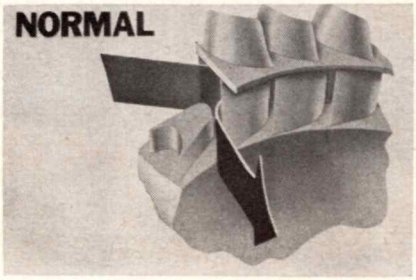


Fig. 3—Effect of overspeed control is minimized during normal operation of pump.

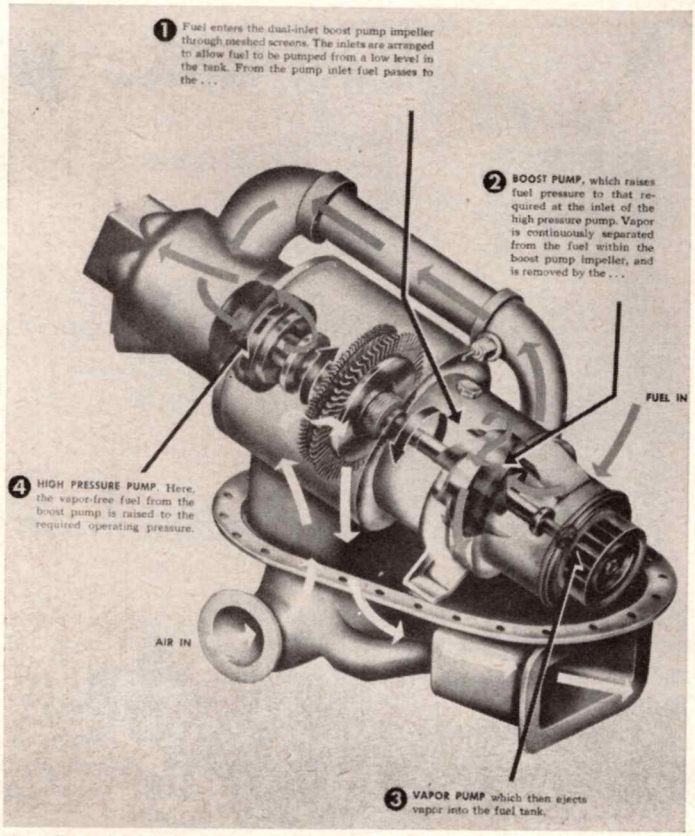

1 Fuel enters the dual-inlet boost pump impeller through meshed screens. The inlets are arranged to allow fuel to be pumped from a low level in the tank. From the pump inlet fuel passes to the . . .
2 BOOST PUMP, which raises fuel pressure to that required at the inlet of the high pressure pump. Vapor is continuously separated from the fuel within the boost pump impeller, and is removed by the . . .
FUEL IN
4 HIGH PRESSURE PUMP. Here, the vapor-free fuel from the boost pump is raised to the required operating pressure.
AIR IN
3 VAPOR PUMP which then ejects vapor into the fuel tank.

Fig. 4—Diagram showing flow directions of fuel and air.

• • Cooling System

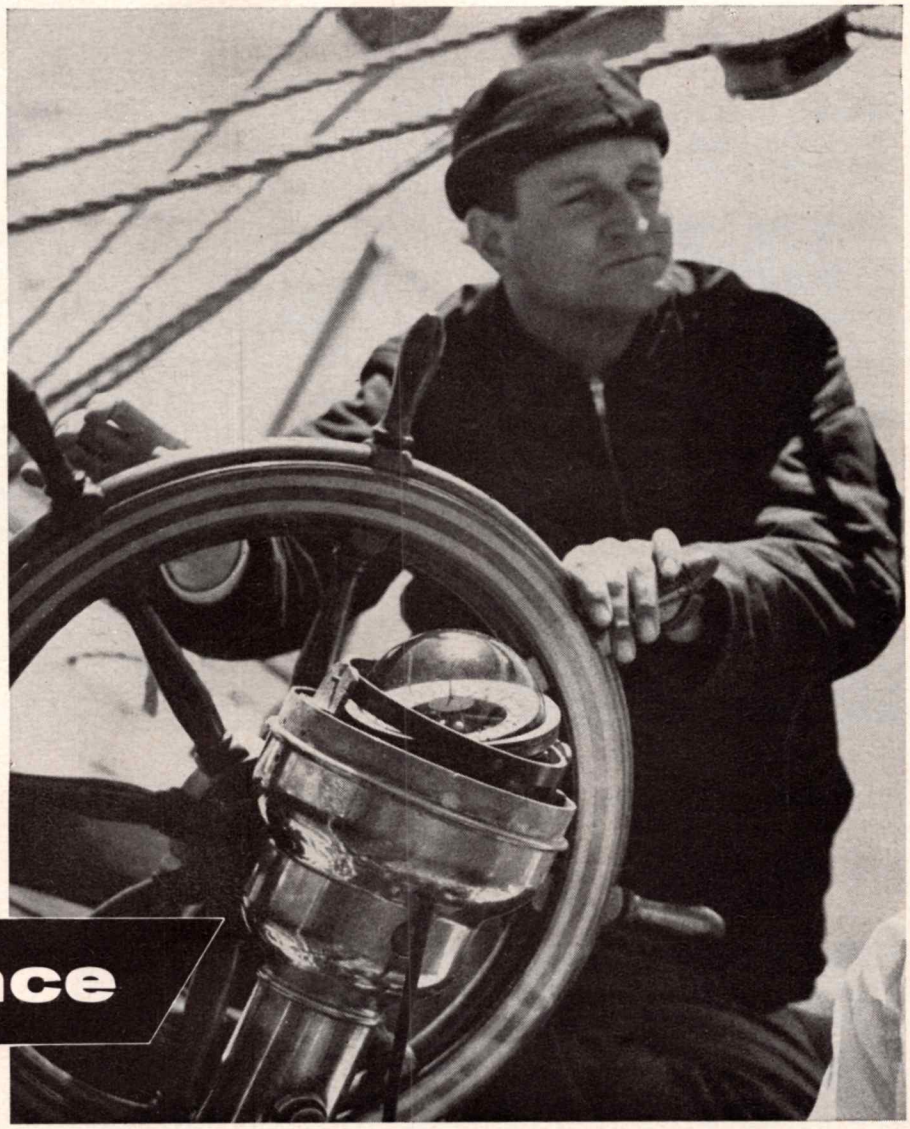
To prevent excess heat rejection to the fuel, the turbo pump incorporates a cooling passageway around the turbine casing, and a built-in aspirator induces ambient air flow around the hot casing. Flight tests have demonstrated that the total heat rejection to the fuel from the turbine casing is negligible.

Bearing problems are always present in designing high speed turbine equipment. An approach toward solving these problems is to keep the loads to a minimum. The high pressure pumping element incorporates a diffuser designed to eliminate high radial bearing loads caused by unsymmetrical pressure distribution around the impeller. Sleeve-type carbon bearings are used throughout the pump. Lubrication and cooling of the bearings is accomplished by use of pressurized fuel extracted from the pump and delivered to the bearings through a series of internal passages. Lubrication discharge flow is returned to a low pressure section in the pump.

• • Installation

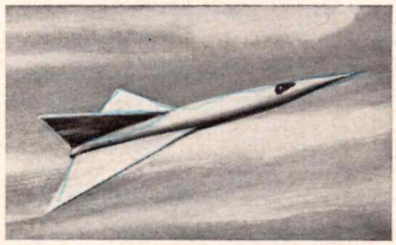
The turbo pump has to operate only when afterburner fuel supply is required. This is made possible by a pneumatic connection rather than a mechanical connection to the main engine. When using a continuous operating afterburner pump that is mounted on the gear pad of the engine, it is necessary to recirculate the fuel during dry engine operation, which results in lost energy and a decrease in useful life. The intermittent operating feature of the tank-mounted turbo pump reduces frequency of overhaul.

The major portion of the turbo pump is located within the fuel tank with only the necessary air connections protruding below the tank. The unit can be installed into the fuel tank by means of a flanged surface on the pump. The pump is inserted into the flanged opening and secured with standard mounting bolts. The high pressure fuel discharge line is the only internal tank connection required for pump installation. END



experience

plays a vital role in every success



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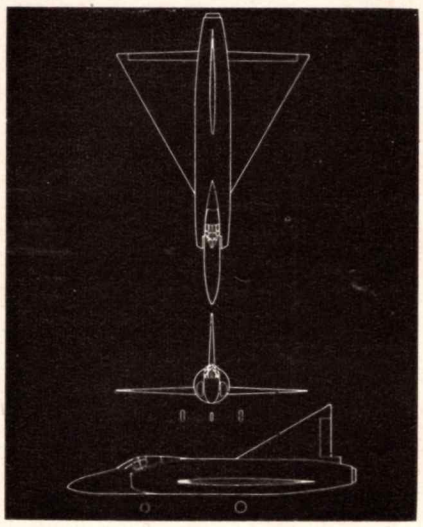
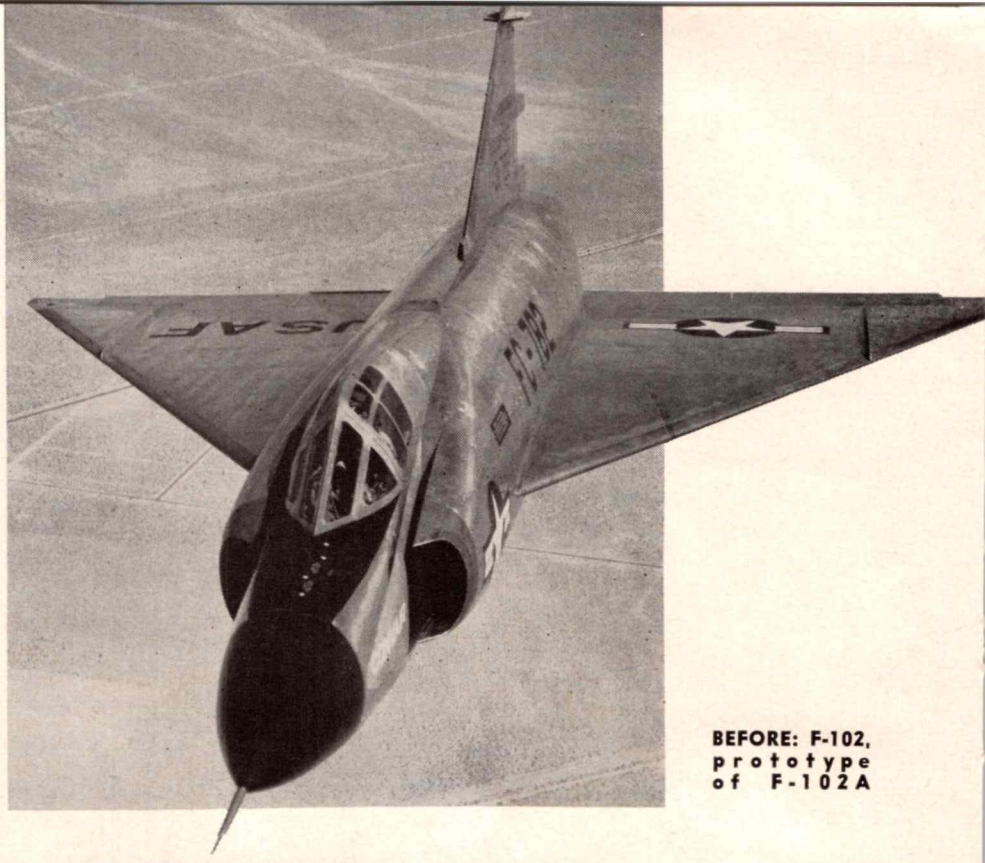
Changes from prototype include longer fuselage, modified wing, and redesigned canopy.





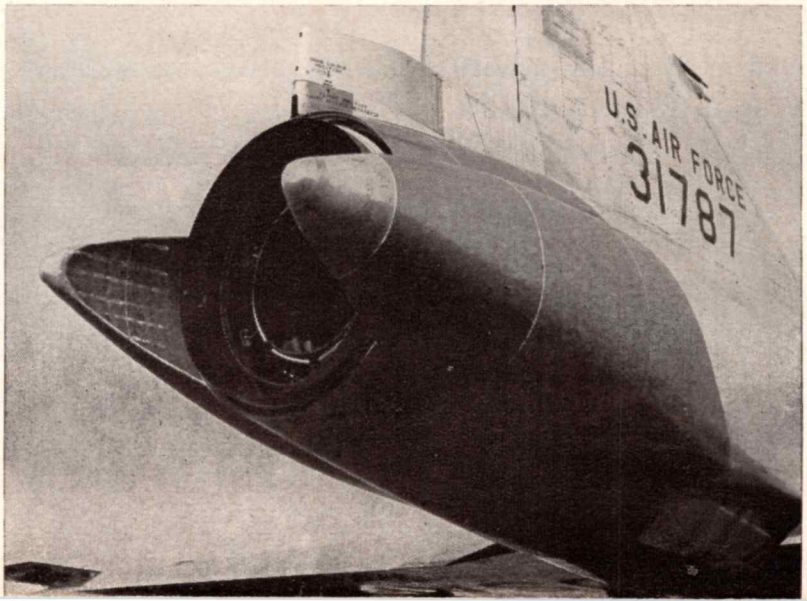
BEFORE: F-102, prototype of F-102A

DELTA WING F-102A

Derived From Convair's Prototype F-102

AFTER: F-102A shows redesigned canopy and swept up wing tips.

Close-up of aft end of fuselage shows streamlined fairings in afterburner area.

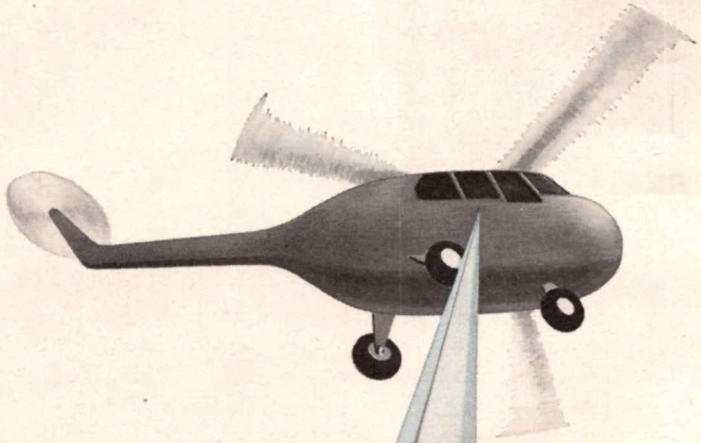


CONVAIR'S F-102A, modified version of the delta-wing F-102—first supersonic all-weather interceptor built for the Air Force—was flown supersonically in level flight only six months after design work had been completed and manufacture begun. The plane is powered by a Pratt and Whitney J-57 (10,000 pound thrust) jet engine with afterburner.

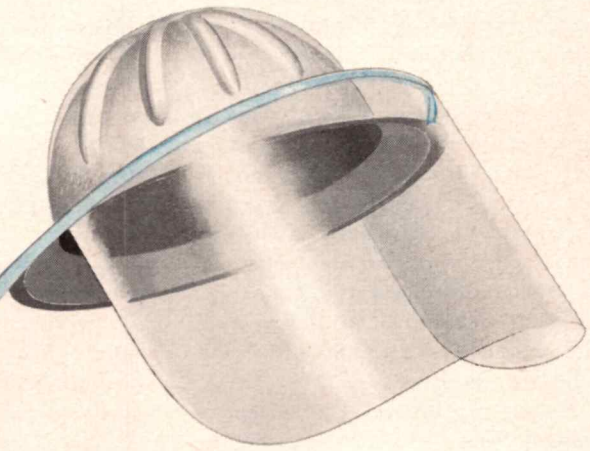
Principal external differences between the new version and its prototypes that have been flying for more than a year is a longer fuselage, cambered leading edge and swept-up wing tips on the delta wing, and a redesigned canopy to give the pilot greater visibility.

It is not believed that the F-102A differs radically from the F-102, which has a wing span of 37 feet; length, 52 feet; height, 18 feet; and gross weight, 25,600 pounds. The prototype was designed for piloted or pilotless flight. It uses the Hughes guidance equipment and mounts the Hughes F-98 *Falcon*, an air-to-air guided missile with automatic radar.

END



from helicopters to helmets . . .



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NAMES IN THE NEWS

Chan Gurney, former Chairman of the Civil Aeronautics Board, has been designated by President Eisenhower as Acting Chairman of the Board.

The appointment of **Dr. Franklin E. Lowance** as Director of Research and Engineering for Westinghouse Air Brake Company is announced by **Edward O. Boshell,** Chairman and President of the company. Dr. Lowance will direct the company's program and coordinate the research and engineering activities of all subsidiaries and divisions.

Robert L. Graham has been appointed Sales Promotion Coordinator of Ford Instrument Company, Division of the Sperry Corporation, and will handle product promotion for the company. New addition to Ford Instrument is **Lawrence S. Brown** who has joined the staff as a Project Engineer.

Lawrence S. Brown

O. E. Esval has been named Vice President and Chief Engineer of Sperry Corporation's Wright Machinery Company, Durham, N. C. **Percy Halpert** succeeds Mr. Esval as Engineering Director for Aeronautical Equipment of the Sperry Gyroscope Company, Great Neck, N. Y.

Robert E. Gross, President and Board Chairman of Lockheed Aircraft Corporation, Burbank, Calif., has been elected President of the Institute of the Aeronautical Sciences for 1955.

Wilson H. Benson has been named superintendent of aircraft maintenance, overhaul and modification operations at Temco Aircraft Corporation's Dallas plant, President **Robert McCulloch** announced.

Otto K. Weltin, formerly Chief of Radar and Communications System, has been appointed Assistant Director of Cook Research Laboratories, Skokie, Ill., a division of Cook Electric Company, Chicago.

Glenview Metal Products Company, Delanco, N. J., has appointed **Frank H. Horn,** Manager of Sales and Service for its "FlyRide" helicopter. Mr. Horn will also supervise a flight instruction program and a training-maintenance program for mechanics.

Samuel A. Gray and **Robert C. Rogers,** formerly with Bell Aircraft Corporation, Buffalo, N. Y., and **H. H. Koppenhafer,** formerly of General Controls Company, have joined the Sales Department staff of Hydraulic Research and Manufacturing Company, Burbank, Calif.

The 1954 Award of the Instruments and Regulators Division of The American Society of Mechanical Engineers has been presented to **Ed Sinclair Smith,** Staff Technical Assistant with the Weapon Systems Analysis Branch, Ballistic Research Laboratories, Aberdeen Proving Ground, Md. This award is presented annually to an engineer for outstanding contributions in the field of instrument and regulator research and development.

The Curtiss-Wright Corporation, Wood-Ridge, N. J., announces the formation of a Research Division under the management of **Kenneth Campbell.** This division will also come under the direction of **E. M. Powers,** as Vice President of the Corporation in charge of engineering and research. Mr. Power's duties as Manager of the Wright Division will be turned over to his executive assistant, **J. V. Miccio,** who becomes General Manager of the Wright Aeronautical Division.

Brigadier General Otis O. Benson, Jr., USAF, President of the Aero Medical Association, announced that **Colonel Robert J. Benford,** USAF, will take over the editorship of that organization's official publication, the *Journal of Aviation Medicine.* During World War II, Colonel Benford was air surgeon of the XX Bomber Command, first B-29 organization to attack the Japanese mainland. Later, as commander of the AAF Aero Medical Center in Heidelberg, Germany, he was responsible for collecting all available scientific and historical information concerning wartime achievement of *Luftwaffe* flight surgeons.

Colonel Robert J. Benford

Appointment of **George C. Hussander, Jr.,** as a member of the Military Sales Section of the AC Spark Plug Division of General Motors Corporation is announced by **John A. Goetz,** Sales Manager of Military Products.

Dr. S. W. Herwald, Engineering Manager for Westinghouse Electric Corporation's Air Arm Division, has named **B. H. Vester** as Supervisory Engineer for the plant's Missile Systems Section. In his new post, Mr. Vester will be responsible for advanced circuit design for missile applications.

Avien, Inc., Woodside, N. Y., announced the election of three Vice Presidents to the company's management staff: **Everett M. Patterson,** formerly director of Engineering, became Vice-President, Engineering and Manufacturing; **William O. Boschen** will continue in charge of Avien's sales and service

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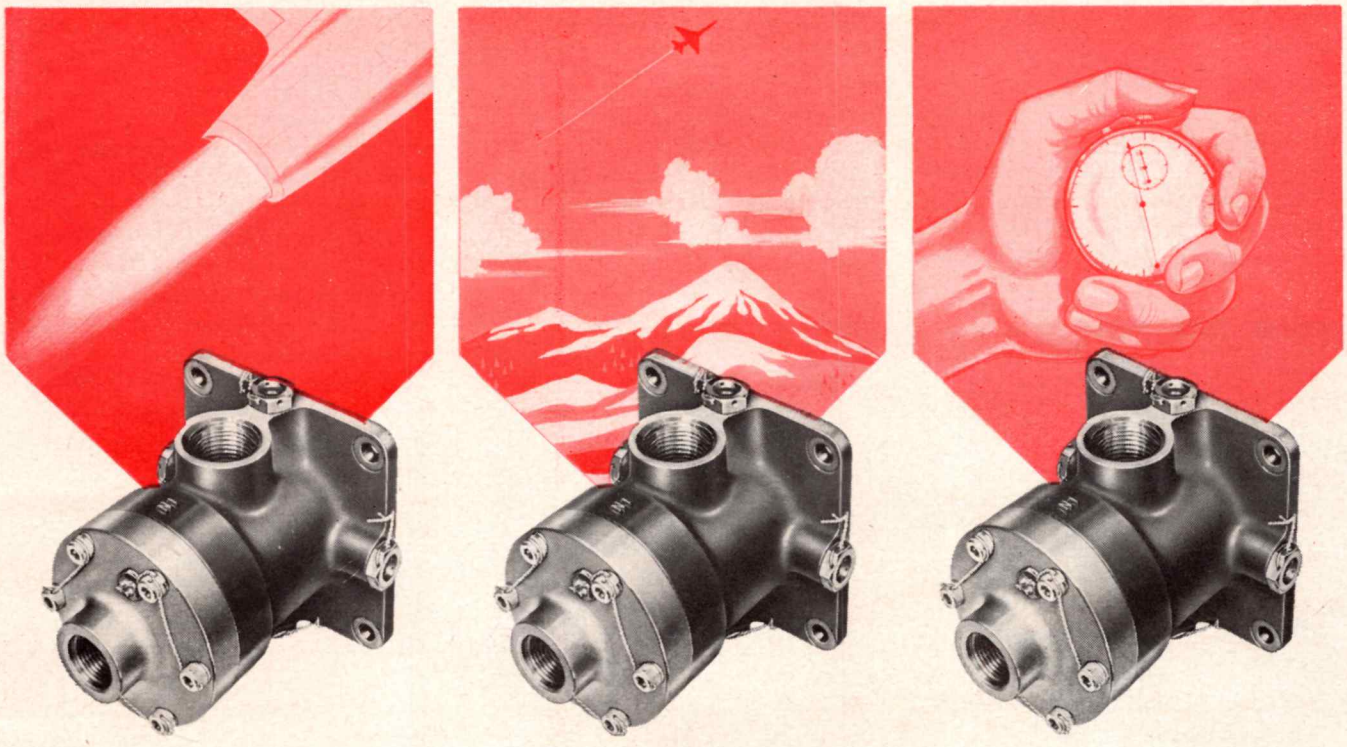

The New Series 66 Fixed Displacement

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HYDRAULIC PUMPS

Design for tomorrow's aircraft...that's the keynote of the new series of STRATOPOWER Hydraulic Pumps. The 66 Series Fixed Displacement Pumps deliver fluid power continuously from sea level to extreme altitudes, permit increased drive speeds and raise the temperature limits of operation—and they raise performance standards of today's planes to new highs in reliability and efficiency.

STRATOPOWER 66 Series Pumps pack more power than ever into extremely small dimensions. They feature a piston actuation mechanism which is positive in action, unaffected by fluid temperatures or inlet pressures...a mechanism which transmits power by means of fewer moving parts and with exceptionally high efficiency at all speeds. These Pumps are designed to meet or surpass the requirements of specification MIL-P-7858. The new 66 Series Pumps have exceedingly high fluid-horsepower/weight ratios. Their low weight will be of prime interest to aircraft designers.

The significant facts about the new Series 66 are important information for every aircraft hydraulic engineer. A STRATOPOWER engineer will gladly give you the facts.

Write for full information on the 66 Series STRATOPOWER Pumps and other new STRATOPOWER developments.

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organization as Vice-President, Sales; **H. Hawley Myers** was appointed Vice-President and Treasurer.

Jerome C. Hunsaker, Chairman of the National Advisory Committee for Aeronautics, announced the appointments of four top Northrop Aircraft scientists and engineers to NACA committees: **Dr. William F. Ballhaus,** Chief Engineer, to the NACA committee on aircraft construction; **Frank B. Bolte,** Chief of Engineering Test, to the sub-committee on aircraft structural materials; **George N. Mangurian,** Chief of Structures, to the sub-committee on aircraft structures; and **Ralph B. Davidson,** Assistant Chief of Structures, to the subcommittee on aircraft loads. Both Bolte and Davidson served on the same committees last year and have been reappointed for the 1955 term.

Raymond F. Darney has joined the sales department of Flex-O-Tube Division of Meridan Corporation to supervise the company's aircraft product activities and to coordinate Flex-O-Tube's research and development program with the requirements of the USAF, USN, USMC, and civilian aircraft manufacturers.

Promotion of **Robert L. Rod** to Assistant to Vice President of the Bogue Electric Manufacturing Company has been announced. Previously Mr. Rod was Assistant Director of Research and Development and headed the company's activities in the development of electronic devices; he now will assist **John A. Herbst,** Vice President—Engineering, in the administration of engineering activities.

Malcolm P. Ferguson, President of Bendix Aviation Corporation announced the formation of the Aircraft Products Division of the corporation's wholly-owned subsidiary, Bendix-Eclipse of Canada, Ltd. General Manager of the new Canadian operation will be **J. F. Taylor,** formerly with A. V. Roe, Canada, Ltd. Two key appointments in the Guided Missile Section of Bendix have been announced: **A. C. Omberg** has been named Assistant General Manager and **W. P. Bollinger** has been promoted to Assistant Director of Engineering.

J. F. Taylor

Republic Aviation Corporation, Farmingdale, N. Y., announced the election of **John A. Thompson** as Secretary of the company; **Thomas Davis,** long-time Secretary-Treasurer, will now devote full time to his duties as Treasurer. Republic also announced the appointment of **George B. Estes** as Chief Industrial Engineer and **D. Alan Kendall** as Assistant Production Manager.

The appointment of **J. E. Barfoot** as Project Engineer-Structures, on the Boeing Airplane Company's KC-135 jet tanker program has been announced by **Maynard Pennell,**

First One-Piece
Molded Construction
MS 21919
Wedge Clamp
WEDGE CANNOT FALL OFF!
FULL CIRCLE GRIP
Stock in all sizes with general purpose, fuel resistant and high temperature rubber.
THE UNIVERSAL ANSWER
ENGINEERING, MACHINING, WELDING, METAL STAMPINGS, AIRCRAFT PARTS
A WORLD OF KNOW-HOW
Universal
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Chief Project Engineer-Aircraft. Barfoot will assume the duties of **Donald Finlay** who earlier was named Chief of Preliminary Design.

A. Paul Vance has joined the Functional Fluids Section in the Sales Department of Monsanto Chemical Company's Organic Chemicals Division, it was announced by **John L. Hammer, Jr.,** Director of Marketing. Vance will specialize in the sale of Skydrol, the company's synthetic fire-resistant aircraft hydraulic fluid, and similar products.

Three promotions in the Purchasing Department of the Convair Division of General Dynamics Corporation, San Diego, were announced by **B. P. Gibbons,** manager of materiel: **Harold N. May** was appointed General Purchasing Agent; **W. G. Evans** was promoted to Purchasing Agent; and **Edward Fellows, Jr.,** was named Purchasing Services Administrator.

Harold N. May

John Herbert Hollomon, Manager of the Metallurgy Department, General Electric Research Laboratory, has been named by the National Junior Chamber of Commerce as one of America's 10 outstanding young men of 1954. Dr. Hollomon was honored for his leadership in metallurgy and metallurgical research, and for special service to his country in war and peace.

The appointment of **J. S. Parker** as General Manager of the General Electric Company's Aircraft Gas Turbine Division was announced by **C. W. LaPierre,** Vice President in charge of the company's Atomic Energy and Defense Products Group. Mr. Parker will be responsible for the operation of five departments within the Aircraft Gas Turbine Division, with headquarters in Cincinnati and Lynn, Mass. END

Quality, Economy, Delivery

from **Jennies** to **Jets**

Demonstrated and proved ability to produce quality products . . . at economical costs . . . and delivery where and when you want them has been a big factor in Kawneer's success in the aircraft industry.

From World War I when we first developed streamlined steel tubing for struts and empennage frames, we've never stopped gaining good solid experience . . . experience that now enables us to efficiently produce complete cockpit enclosures, and other assemblies for jet aircraft.

Kawneer's recently built 110,000-square-foot plant, manned by a well qualified management team and abundant skilled manpower, is 100 percent privately financed, proof that we are in the aircraft business to stay. All our new machines and equipment were planned and purchased to give Aircraft Producers and U. S. Government Procurement Agencies a dependable money-saving source.

We invite your inspection at any time. But if you cannot visit us, we'll be glad to send our illustrated brochure or have one of our qualified representatives call on you.

SINCE 1907, FABRICATORS OF METAL AIRCRAFT ASSEMBLIES AND ARCHITECTURAL PRODUCTS

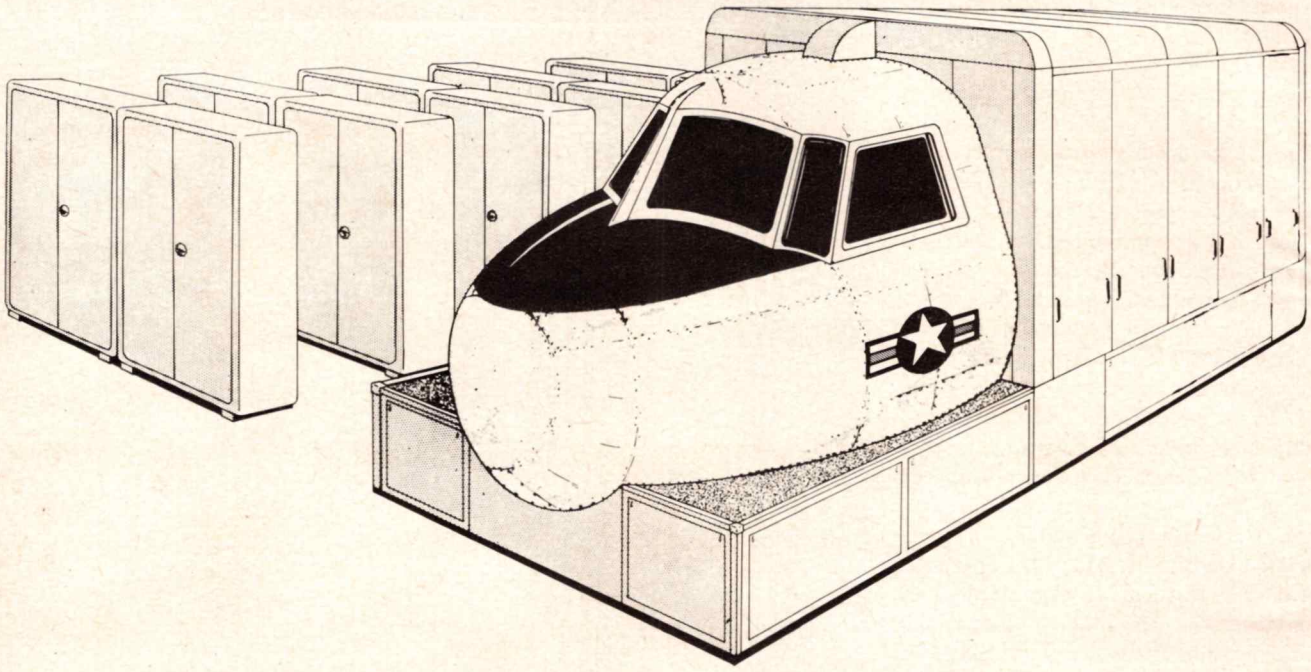


Fig. 1—Drawing of units housing C-121 Lockheed *Super-Constellation* Simulator. Cockpit, control consoles, and flight recorders are housed in the large cabinet. Small cabinets contain the computers and power supplies.

Non-linear potentiometers produce new standards of fidelity in FLIGHT SIMULATORS

Servo units controlling non-linear, high resolution potentiometers of novel design, produce signals closely analogous to the equations of motion of an aircraft. Used with digital computers, servos transmit to appropriate circuits the effects of engine and weather conditions on aircraft flight.

By HENRY P. STEIER
Electronics Editor

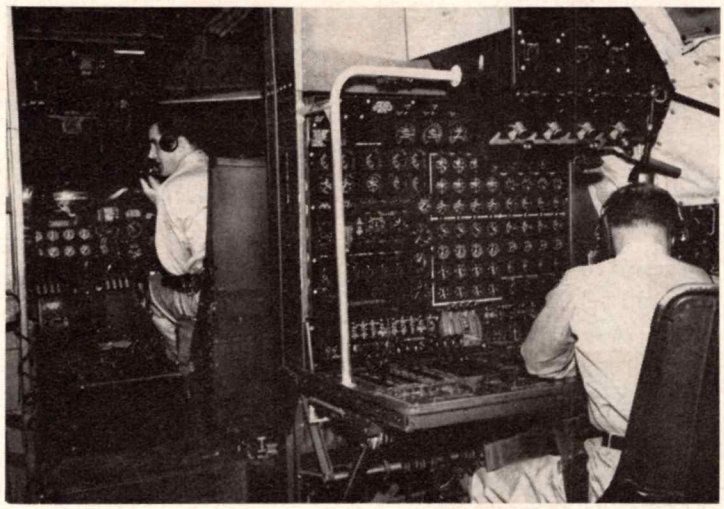
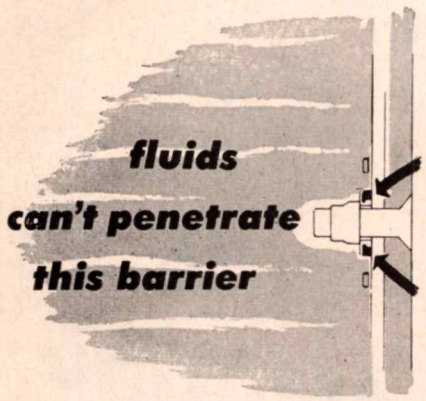


Fig. 2—Interior view of simulator's cockpit. Left, pilot's compartment. Right, engineer's compartment. Crew positions, instruments, and controls duplicate those of C-124 Douglas *Globemaster*.

FLIGHT SIMULATION, with training devices that produce synthetically the aerodynamic and operational conditions, and mission circumstances of an aircraft with excellent fidelity, is radically changing the statistics dealing with air crew training costs together with the safety records.

A flight simulator is an electromechanical device that produces flight, engine, navigational, and some psychological conditions and environments of specific aircraft. Physically, the device consists of a control cabin that duplicates that of a particular aircraft, and a series of cabinets containing analog and digital computers, summing amplifiers, noise generators, and power sup-

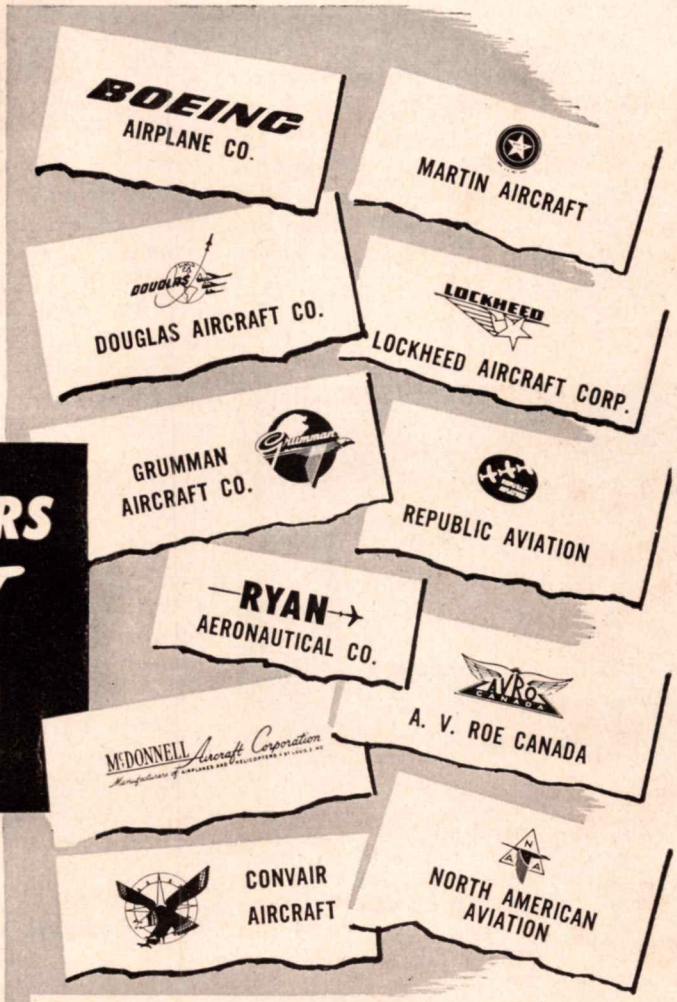


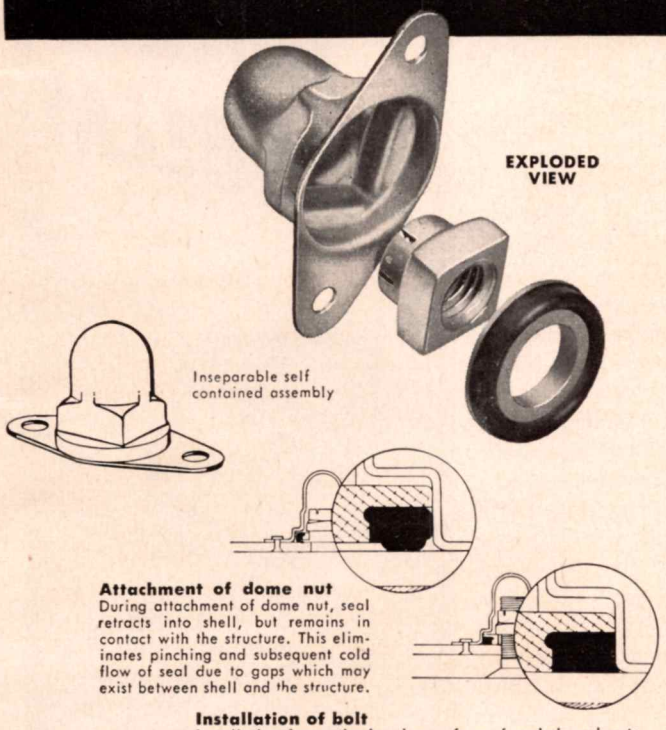
fluids can't penetrate this barrier

IN THIS SELF-SEALING DOME NUT

11 PRIME MANUFACTURERS Specify THIS NUT

for integral fuel tank sealing on aircraft in production





Attachment of dome nut
During attachment of dome nut, seal retracts into shell, but remains in contact with the structure. This eliminates pinching and subsequent cold flow of seal due to gaps which may exist between shell and the structure.

Installation of bolt
Installation forces the bearing surface of sealed washer to contact the structure, providing positive single point sealing.

FEATURES

- ★ High pressure sealing without sealing compounds
- ★ Inseparably self-contained assembly
- ★ Single point seal
- ★ Floating nut with stationary seal, unaffected by successive bolt installations
- ★ Reduces Installation Time Weight and Maintenance

SPECIFICATIONS

Self locking nut conforms to applicable requirements of AN-N-5. Floats .025 in all directions.

BUNA-N type seal conforms to requirements of MIL-R-6855 for aircraft fuels Type 1, 2 and 3. It is also resistant to air, salt water, oil, gasoline and most organic solvents. Temperature range: −80°F to +225°F continuous operation. Pressure range ±50 psi constant or fluctuating operation.

SILICONE type seal. Resistant to hot air, ammonia, synthetic oil. Temp. range −80°F to +450°F continuous operation.

The range of materials and sizes now available has been greatly expanded. Pick the part number that meets your specific requirements from the following chart of production types.

Thread Sizes	Steel shell & nut; aluminum washer; Buna-N seal	Steel shell, nut & washer, Silicone seal	Steel shell aluminum nut & washer; Buna-N seal	Corrosion-resistant steel shell & nut; aluminum washer; Buna-N seal
6-32 NC-2	4630H-62	4630HA-62	—	4730H-62
8-32 NC-2	4630H-82	4630HA-82	—	4730H-82
10-32 NF-3	4630H-02	4630HA-02	—	4730H-02
1/4-28 NF-3	4630H-048	4630HA-048	4530H-048	4730H-048
5/16-24 NF-3	4630H-054	4630HA-054	—	—
3/8-24 NF-3	4630H-064	4630HA-064	—	—

NOTE: Any combination of shell, nut, washer and seal materials shown above can be readily assembled for your specific requirements.

Also available in special gang channel designs.

REDUCE YOUR COSTS. Our 12 years' experience with *specialized* fasteners can help you.

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Manufacturers of self locking anchor nuts and special fasteners.

plies. In the rear of the housing containing the control cabin are *Trouble Consoles* which introduce various static and dynamic flight conditions, and mechanical difficulties into the simulated flight. *Course Recorders*, of the moving pen type, are provided to chart the flight path of the aircraft during the execution of all maneuvers, Fig. 1, 2 and 3.

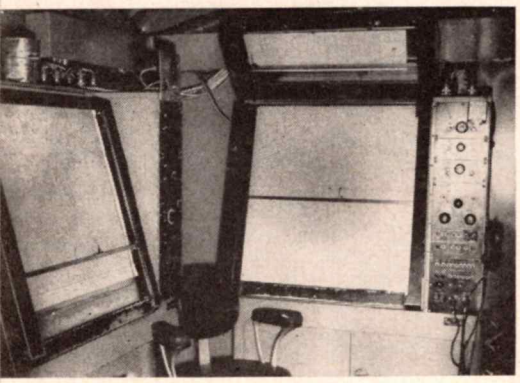


Fig. 3—Course recorders in instructor's section of cabin. Left, large scale chart for airport glide path recording. Right, small scale chart for large area flight path recording.

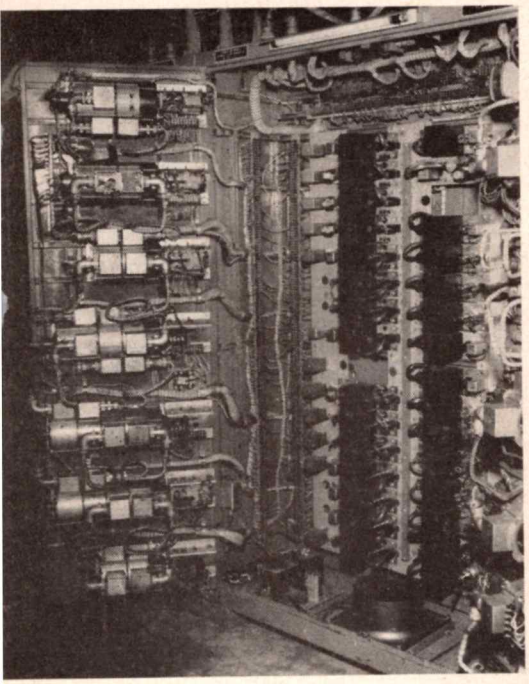


Fig. 4—Flight computer cabinet on the left mounted on door, servo units for *pitch, angle of attack, wing-flap, true airspeed*, and other flight-factor information generation. Inside cabinet are integrating and summing amplifiers to process data produced.

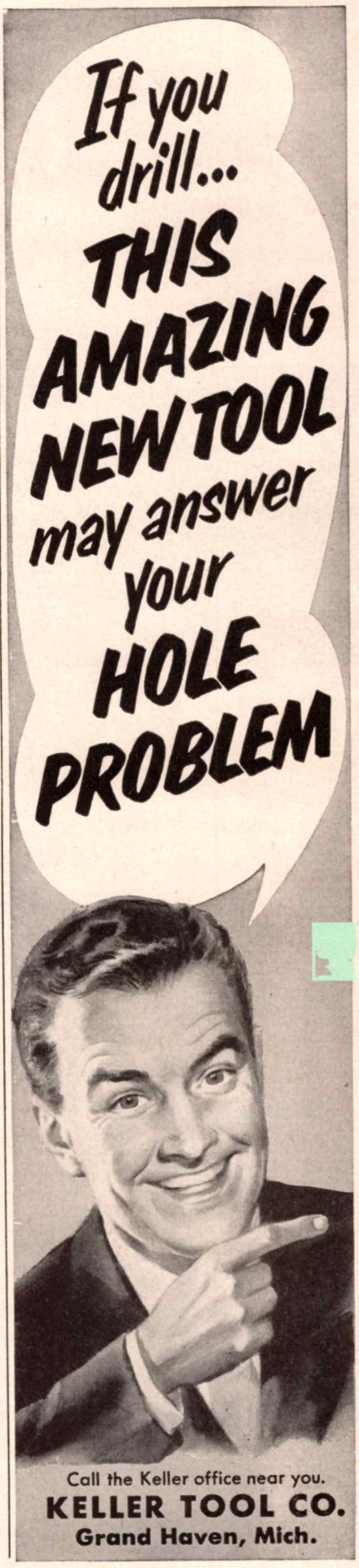
The computers are housed outside the control cabinet housing, and are grouped in cabinets according to functions such as *Engine Number 1, Flight, Radio-Aids, Noise, and Control Force*, Fig. 4.

The computers are the heart of the simulator. In the Curtiss-Wright *Simulator* a new standard of simulation fidelity is claimed through use of high resolution non-linear potentiometers used in conjunction with conventional servo units. Non-linear potentiometers, stacked in some cases on a common shaft, provide resistance characteristics that permit electrical equations to be set up in a form analogous to a given set of differential equations. The equations may correspond, for example, to the longitudinal equations of motion of the airplane. Wire, wrapped around a phenolic card cut in the shape of a calculated curve, see Fig. 5, gives the potentiometer its non-linear characteristic. The card is wrapped around a cylindrical frame in order to form a rotary element that can be turned by a servo unit.

• • Computers

Engine operation is electrically simulated in the engine computer cabinets, Fig. 6. There is a computer cabinet for each engine, which contains the computer units that generate engine factors affecting engine power, efficiency, and sound. For example, engine conditions that are affected by carburetor settings, propeller pitch settings, and so forth, are generated electrically. After mixing, the information is presented to the appropriate cockpit instruments as well as to the *Flight, Control Force*, and *Sound* computers. These computers process the data and generate electrical signals that effect the aircraft's control response, attitude, speed, *feel* of the controls, and sound within the aircraft.

A *Radio Aids* computer unit simulates high and low radio frequency signals. This permits simulation of navigation facilities for any area throughout the world. Course, approach, and altitude recorders chart the flight path during the execution of all maneuvers. The recorders permit the instructor to view the details of the flight path as drawn by a moving pen on both a large-scale chart for airport glide paths, or a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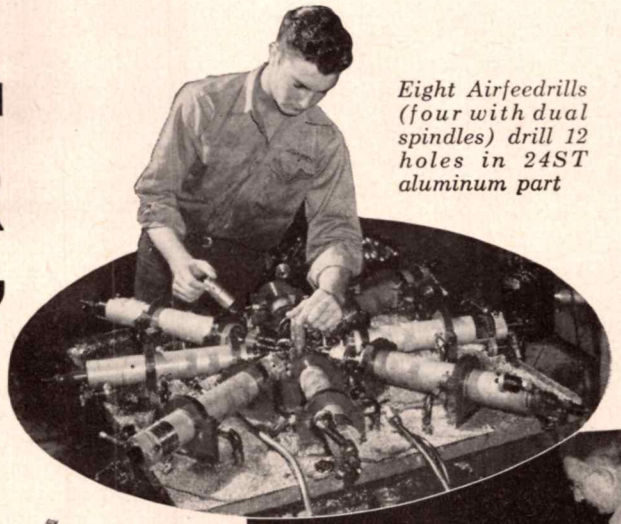
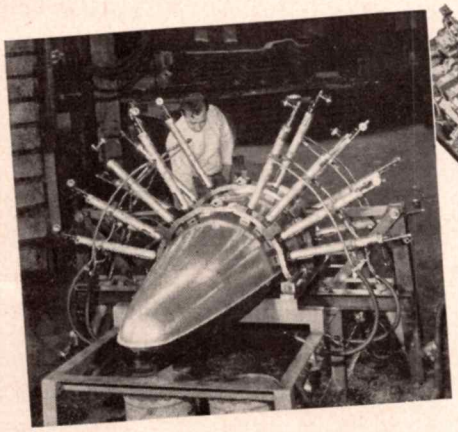
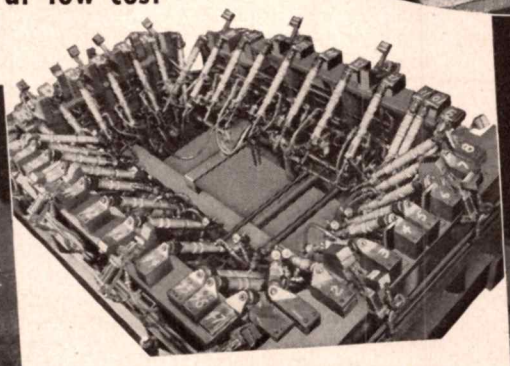
Low investment and easy change-over make Airfeedrill setups the ideal way to make accurate holes at low cost



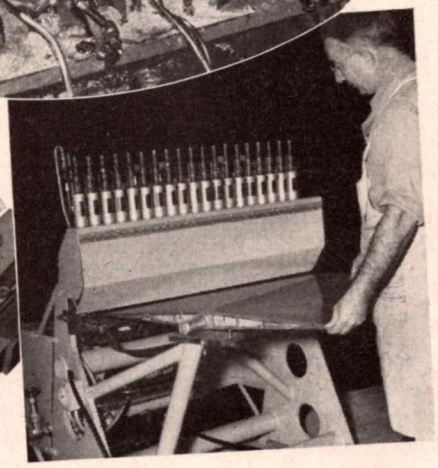
Eight Airfeedrills (four with dual spindles) drill 12 holes in 24ST aluminum part



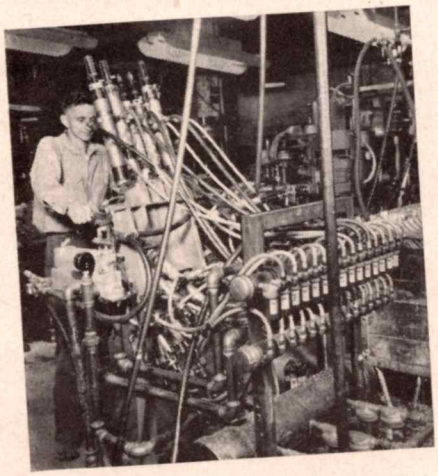
Sixteen holes made simultaneously on teardrop gas tank. Note the drilling angles



47 Airfeedrills on a single fixture for making trim holes in automobile roof panels



Fixture with 19 Airfeedrills used on guided missile fins at an aircraft plant



Fixture with 16 Airfeedrills used on section of automobile instrument panel

Here is the new way to handle multiple drilling jobs without investing in expensive machine tools. Simply build a fixture on which to mount Keller Airfeedrills . . . connect them with your air supply . . . and you are in business.

When the job has been run, the Airfeedrills are detached for use on another job. Where jobs are intermittent or short run, Airfeedrills permit high production where no other multiple drilling method would be economically feasible.

If you are not acquainted with the remarkable possibilities of Keller Airfeedrills, send for information without delay. Ask for Catalog Sections 92 and 92A.

KELLER "Airfeedrills"

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DIVISION OF **GARDNER-DENVER**

GARDNER-DENVER Since 1859

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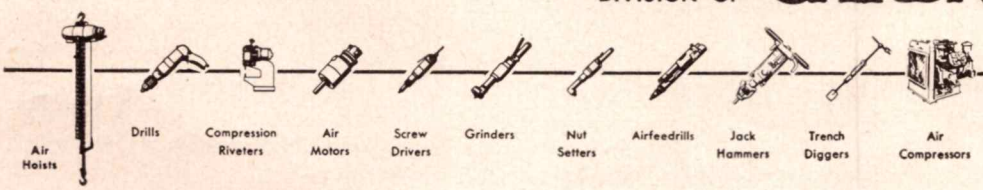

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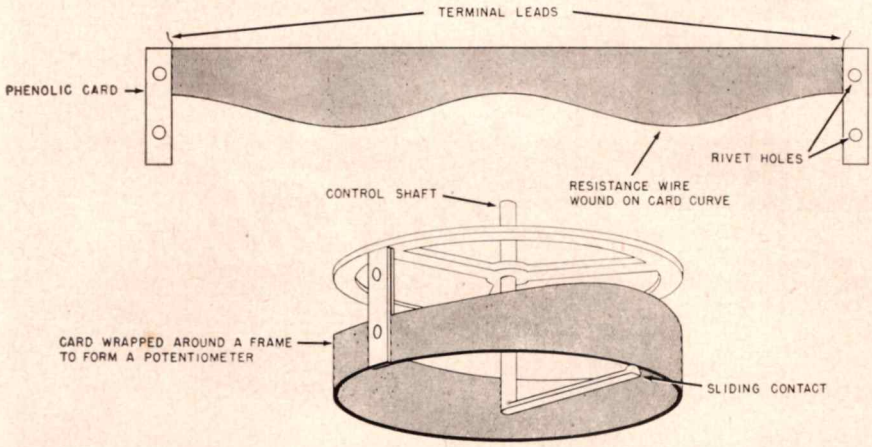


Fig. 5—Drawing of potentiometer card showing curved shape around which resistance wire is wound, and drum type potentiometer frame around which card is formed.

small-scale chart covering the flight path over large areas. The Radio Aids Facilities Console, see Fig. 7, controls the radio signals and permits introduction of transmission or reception problems and difficulties into the aircraft's radio system.

Simulated radio facilities include: low-frequency AN range stations, Z markers, fan markers, low-frequency locators, omni-directional stations, complete instrument landing systems (ILS and GCA) with movable markers and adjustable glide slope angle, offset course computer, and universal station identification keyers.

● ● Trouble Console

The *Trouble Console*, under control of the instructor, is the control center at which the instructor sets the flight, engine, or radio conditions for the aircraft. Wind velocity, air turbulence, aircraft weight or center of gravity, icing, or emergency conditions such as fire, runaway propeller, and other abnormal circumstances can be established here, Fig. 7. Some simulators have artificial lightning flashes and hailstorm sounds provided to inject further realism into the training. Information from all computer units is interchanged among them and combined so that the pilot and crew may *see*, *hear*, and *feel* the aircraft's condition and attitude in the simulated flight.

● ● Training Values

Since the end of World War II airplanes and their supporting equipments have become so complex that ordinary flight trainers are no longer adequate. Complexity of the modern airplane makes it difficult and costly to train crews for an acceptable level of proficiency. In 1946, the Air Force purchased a simulator capable of teaching not only instrument flight but also the techniques of transitional training. The first purchased simulator was designed to simulate the operation and performance of the F-80 *Shooting Star*.

Since 1948, the Pan American Airlines and other airlines have simulators to train aircrews for specific commercial aircraft. Early tests of the Boeing 377 Simulator, in which the Military Air Transport Service participated, indicated that the 377 simulator eliminated 50 percent of air transition training time in the military version of the 377, the C-97. It is claimed that the reduction in actual flying hours produced savings of $1.5-million per year for a Simulator that produced 4680 hours of flight training time. The new MATS C-124 Simulator costs less than a million dollars.

Experience by MATS with the C-97 and other Simulators indicates that simulators are valuable devices not only for decreased costs and flying hours in training programs, but also for reduced accident rates.

Fig. 6—An engine computer cabinet, showing on the left and mounted on the door, servo units for *torque*, *fuel pressure*, *manifold absolute pressure*, *fuel air mixture*, and other engine-factor information generation. Inside the cabinet are integrating and summing amplifiers.

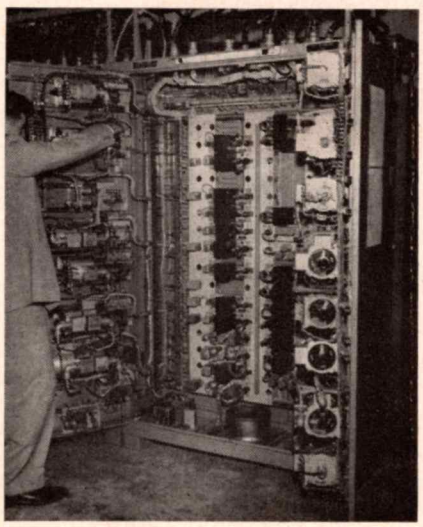
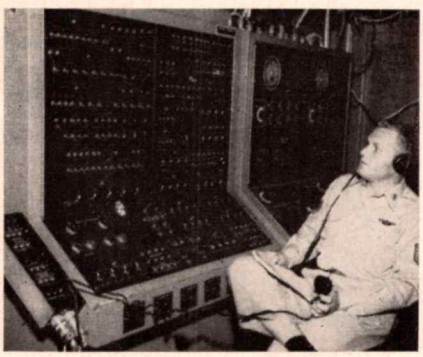


Fig. 7—The instructor's *Trouble Console* (left) and *Radio Console* (right) for setting up flight, radio, and emergency conditions.



● ● Future of Simulators

The use of simulators is developing, and statistics are being collected as to the best ratio of simulator to actual flight hours for different types of aircraft, together with data on criteria, revealed in simulator training, for judging psychological and technical aptitude of trainees.

MATS experience with the Curtiss-Wright Simulators shows that trainees react psychologically to the devices in about the same way they would in actual flight. This effect is attributed to the fidelity of simulation provided in the latest models, even though, for example, the effects of gravity forces are not produced.

The program for procurement calls for *in phase* production of simulators with airplane buying programs so that the simulators will be available 90 days prior to deliveries of the plane it represents. Also, the Air Force is currently working to establish closer cooperation between simulator and airframe manufacturers. END

Extrusion Presses

Giant extrusion presses, reported capable of producing the largest extruded aluminum shapes in the world, are being installed in the Torrance, California, plant of the Harvey Aluminum Company.

The extrusion presses were designed primarily to produce single piece airframe members into shapes up to 80 feet long and 25½ inches wide. By using special extruding techniques, panel type shapes in single sections as wide as 60 inches will be able to be produced.

Production of heavy press aluminum extrusion with greater cross-section, weight, and length dimension will reduce fabricating and machining time and allow substantial manufacturing economies.

Part of a joint participation program under the Air Force heavy press program, construction is marked for early completion and production is scheduled for mid-year. END

Delay Control With TelAutograph

Factory trouble and shortages that could cause schedule delays on production of the Northrop F-89D *Scorpion* can now be reported instantaneously through use of a new TelAutograph telescriber system installed at the company's Hawthorne plant.

The telescriber which transmits handwritten communications from one point to another is operated electrically. The system eliminates the use of telephone service for reporting any problems which could cause delay. All information is transmitted to a central control department which can take immediate steps to rectify the problems or delays.

All shortage reports from the outlying areas which are received by the general control department are reconciled immediately by a special group which determines if a shortage actually exists within the plant, or merely within the reporting department.

Northrop is pioneering use of the system for aircraft companies, and anticipates that it will save as much as $175,000 annually. END

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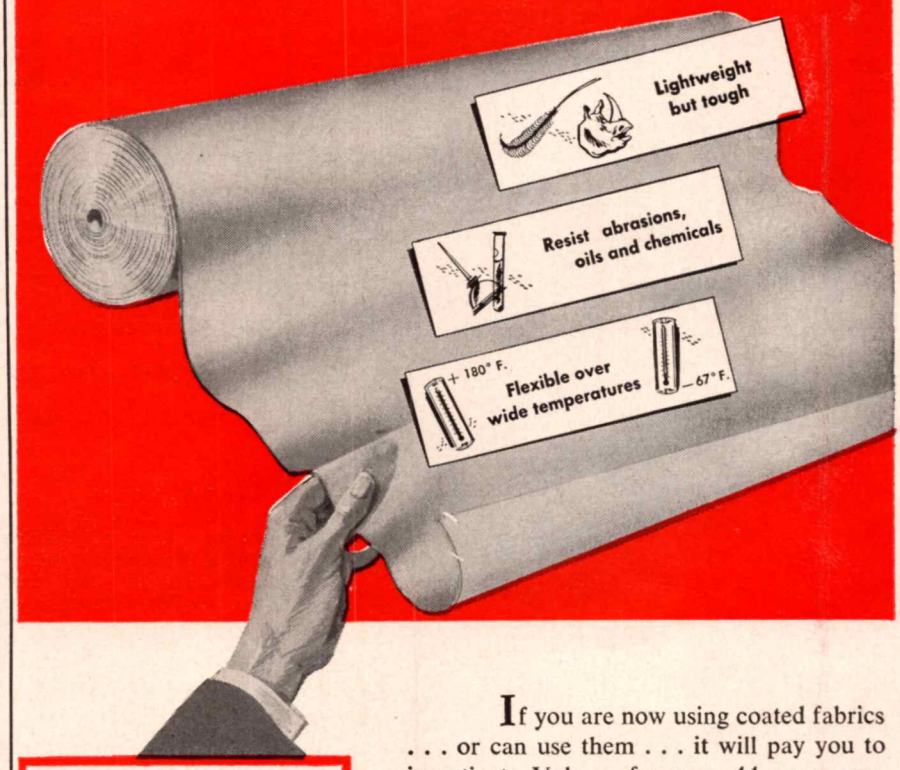
are engineered for their jobs



Vulcan coated fabrics are adaptable for many types of industrial use including:

Air seals
Bearing seals
Cable wrapping
Carrying cases
Carburetors
Control diaphragms
Covers and paulins
Fuel containers
Fuel pump diaphragms
Gaskets
Hospital sheeting
Insulation
Meter diaphragms
Railroad car seals
Regulators
Safety clothing
Soundproofing
Transmission seals
Vacuum pumps

(Many of the items for the above uses are produced to meet the specifications of AMS 3270, AMS 3274-A and MIL C 8068 Type 1)

If you are now using coated fabrics . . . or can use them . . . it will pay you to investigate Vulcan, for over 44 years producer of a complete line of quality industrial coated fabrics.

Lightweight but tough...resistant to abrasions, oils and chemicals . . . flexible over wide temperature changes...these are some of the many *good* reasons for the superior performance of Vulcan coated fabrics.

Used by many of the leaders of American industry, including the United States Government, these fabrics are available with either natural or synthetic coatings.

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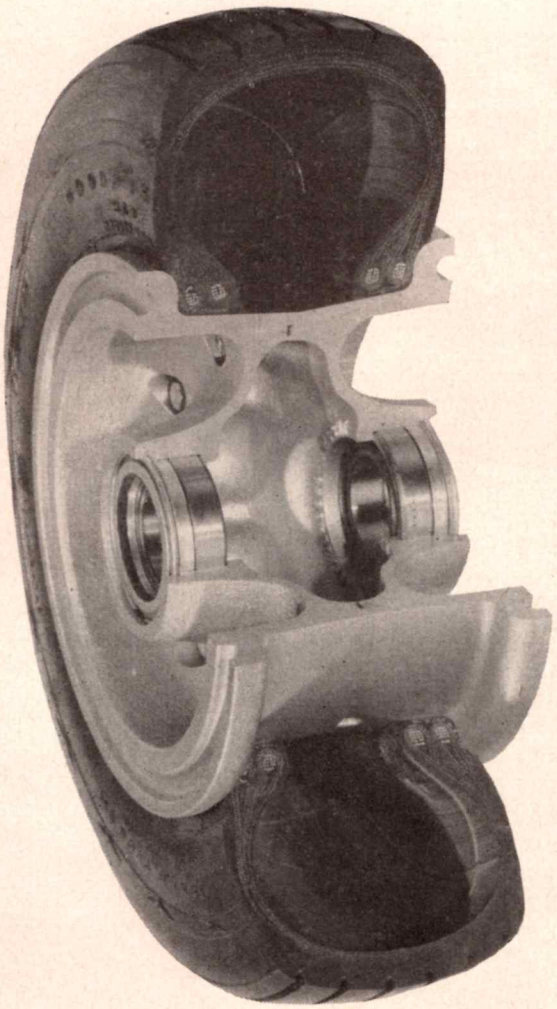


Designing for TUBELESS AIRPLANE TIRES

Advantages claimed for tubeless tires are:

- weight saving
- cooler running than tubed tires
- elimination of tube failure problems, and
- ease of installation.

Cutaway view of tubeless airplane-tire mounted on forged nosewheel. The flat gasket seal on the modified wheel is shown in the center of wheel splits.

TUBELESS TIRES are of increasing interest because of weight savings and product simplification. Weight saving per airplane varies as to the size, type and number of wheels; however, for most purposes the weight saving can be considered to be about 40 percent of the tube weight. An example of what this might mean for three typical size tires is given in Table 1.

The weight saving may amount to as much as 94 pounds on large multiple wheel aircraft.

Use of the tubeless tire eliminates tube and valve problems. Inserting the tube in the casing and placing the valve stem in the valve hole are troublesome operations and care must be used to avoid possible trouble from these sources. For tubeless tires, the valve is made an integral part of the wheel.

An important advantage of tubeless tires for modern military aircraft stems from the fact that tire beads, that portion of the tire structure that fits on the wheel rim, in the small size high pressure tires, are becoming very wide compared to the width available between wheel flanges; and there is insufficient space left for tube and valve. This condition may cause chafing of the tube and tire failures.

Other advantages are that tubeless tires run slightly cooler than conventional tires, and that it is not necessary for users to carry a stock of replacement tubes.

It should be pointed out that in the case of airplane wheels (contrary to most passenger car wheels), certain design provisions must be made in the wheel to seal it from air leakage. Briefly, these provisions are:

1. Impregnated wheel castings to prevent air leakage.

2. Gaskets or "O" rings (Fig. 1) to seal the division in the wheel rim (nearly all aircraft wheels are either the split type or demountable flange type).

3. Proper valve hole design and location.

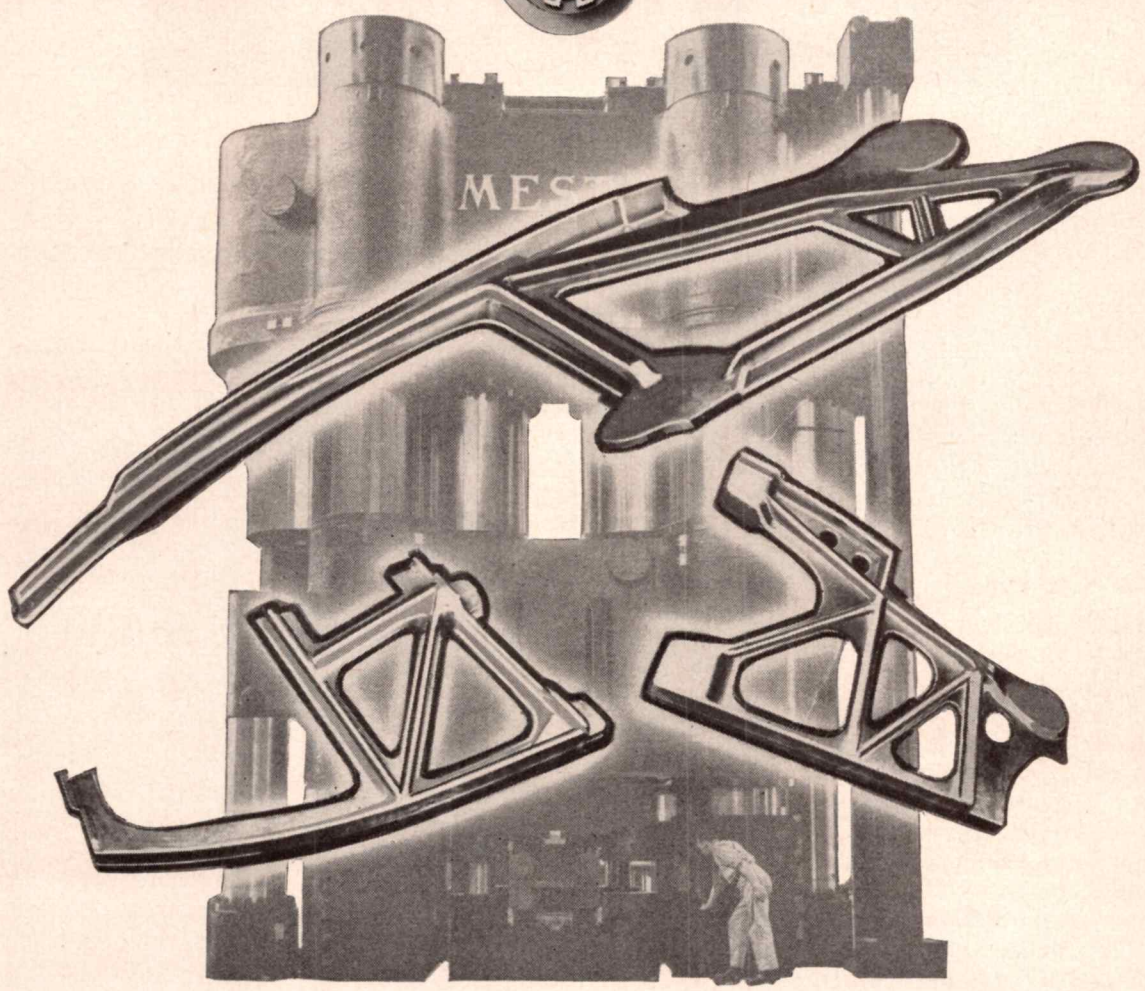
4. Elimination of knurling on the rim.

These features can be incorporated in new wheel design with no design penalty. Furthermore, new wheel designs can usually be made adaptable to either tubeless or conventional design. Although it is possible to adapt certain aircraft wheels that are now in use with conventional tires to use with tubeless tires, this is the exceptional case. END

Table I—Comparative Weights* of Tires

	Conventional Tire and Inner Tube, lb	Goodyear Tubeless Tire, lb
Tire A (Military Fighter)	30	28
Tire B (Commercial Transport)	115	106
Tire C (Military Bomber)	305	294

* For same load rating.



Greater Size and Speed in Aircraft have created engineering problems, the solution of which has required larger and larger forgings of high-strength aluminum alloy. *Examples* shown above are forged structural members used in a modern military bomber, the largest more than seven feet over all. These are forged on an 18,000 ton press, the biggest ever built in this country.

Wyman-Gordon Experience—the most extensive in the industry—is keeping abreast of new forging demands involving the use of Steel, Aluminum, Magnesium, High Density Alloys and Titanium.

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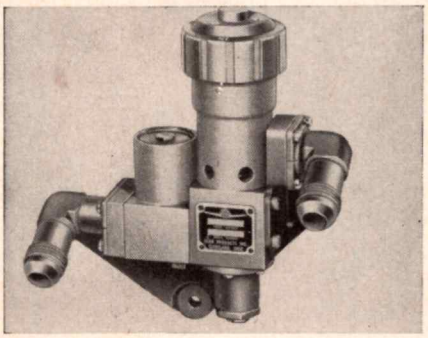
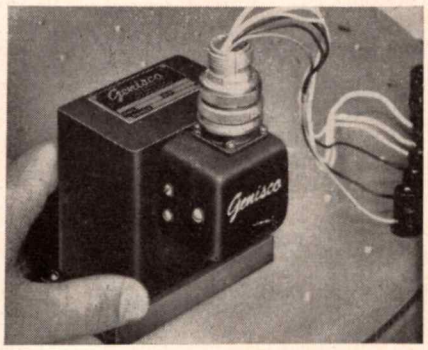
NEW EQUIPMENT



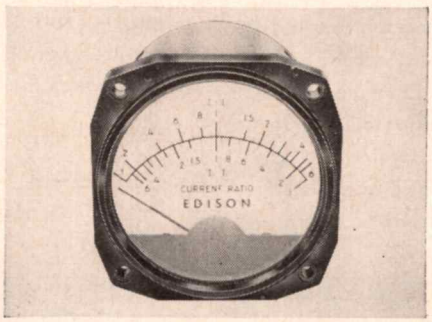
• Anti-G Suit Valve

Engineered and built in accordance with USAF Specification MIL-V-9370(1), the new Alar valve takes air from a jet engine compressor bleed-off (or other compressed gas source), and by automatically regulating the flow provides air at the pressure required to operate a pilot's anti-G suit during periods of positive acceleration. Designed to accommodate inlet pressures of from 10 pounds per square inch to 300 pounds per square inch, and temperatures from 65 degrees Fahrenheit to 400 degrees Fahrenheit, the valve can be adjusted easily for both high and low pressure increments. The valve can be operated manually to aid in combating pilot fatigue. Alar Products, Inc., 1071 Power Ave., Cleveland 14, Ohio.



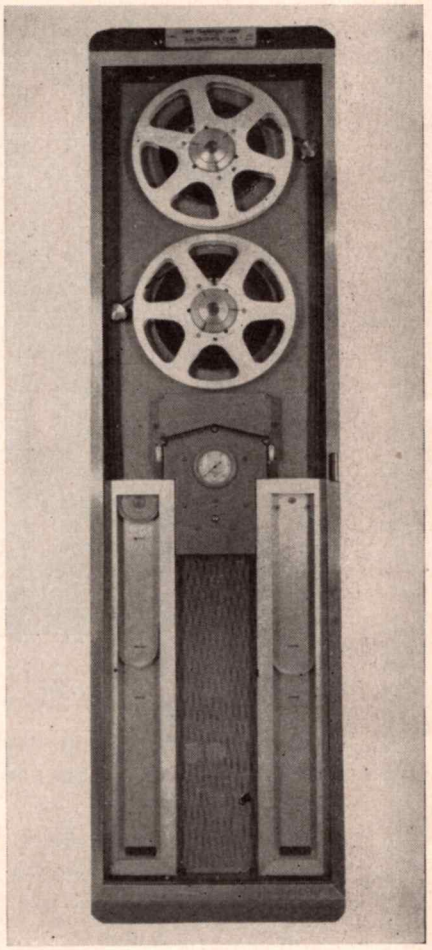
• Accelerometer

A potentiometer type accelerometer, available in ranges of ±1g to ±3g, the Model GOH Genisco instrument is claimed by the manufacturer to maintain constant operating characteristics over a wide temperature range. An internal, thermostatically controlled heater is said to permit operation (within specification limits) between —50 degrees and 180 degrees Fahrenheit without instrument damage or change in characteristics. The mass of the GOH is supported by a parallelogram leaf spring that is claimed to give it a virtually friction-free straight line motion along the sensitive axis; mass travel in all other directions is substantially restrained. Limit stops on four sides of the mass, including the sensitive axis, prevent overtravel. This feature is said to enable the instrument to withstand 40g shocks without damage. It is specified that the unit can be operated at any altitude, but thermostat operation is limited to 60,000 feet and 95 percent relative humidity at 160 degrees Fahrenheit. Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.



• Two-Current Panel Meter

A new Edison panel meter to indicate the ratio of two direct currents has a capacity to handle 50 milliamperes in either coil, and will indicate a ratio on an input of two milliamperes minimum. Scale tolerances are based on an angular tolerance of one degree. With equal current in both coils, the pointer will indicate unity ratio. An increase in strength of one current over the other will pull the pointer right or left of center to indicate a ratio. Thos. A. Edison, Inc., Instrument Div., West Orange, N. J.



• Tape Transport Unit

A recording tape and transport unit for use with digital computer and data processing systems has a capacity of 2400 feet of ½ or ¾ inch magnetic tape at speeds of 30, 40, 50, 60, or 75 inches per second. The Model 546 unit has provision for the installation of two record-read heads, either of which can be selected remotely through mechanical control of the tape engagement mechanism. With standard ¾ inch tape, and Brush series BK 1500N or BK 1300N heads, 18 information channels are available. A vacuum-column con-

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THRUSTMETER
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Convair's F-102
McDonnell's F-101

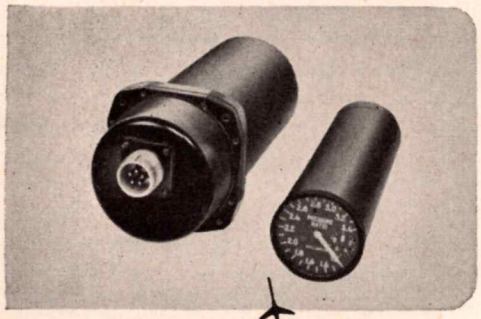
which way* to measure jet engine performance?

THRUSTMETERS

to indicate PRESSURE RATIO
to indicate DIFFERENTIAL PRESSURE

TYPICAL SYSTEM OPERATIONAL DATA

1. Accuracy: .015 in 100% of readings at room temperature.
   .025 in 85% of readings at −55°C and +70°C.
   .035 in 15% of readings at −55°C and +70°C.
2. Altitude: No specific limitation.
3. Power: 115V, 400CPS, single phase, 18VA
4. Pressure Ratio Range: 1.2 to 3.4
5. Pressure Ranges (operating):
   Pt_2=2 to 50″ Hg. Abs.
   Pt_7=2.4 to 100″ Hg. Abs.
   Pt_7-Pt_2=0.4 to 70″ Hg.
6. Temperature Range: −55°C to +70°C.
7. Weights:
   Transmitter: 2.2 lbs.
   Indicator (including integral amplifier): 1.8 lb.
8. Response: Full Range in 7 seconds.



Actual photograph

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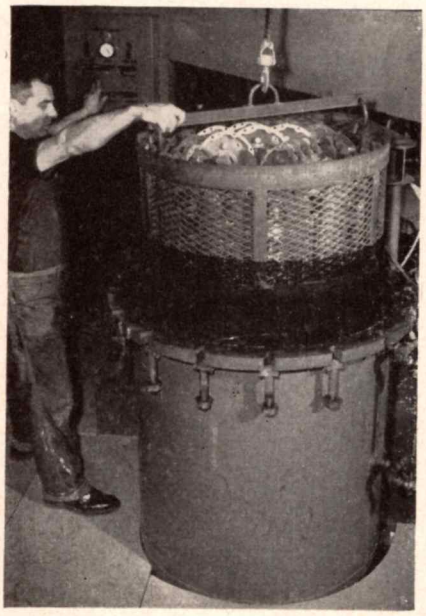

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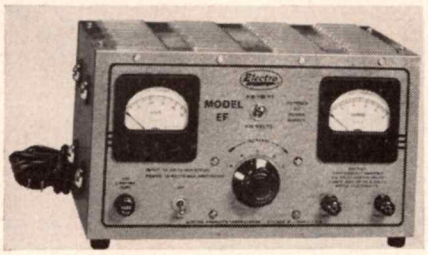
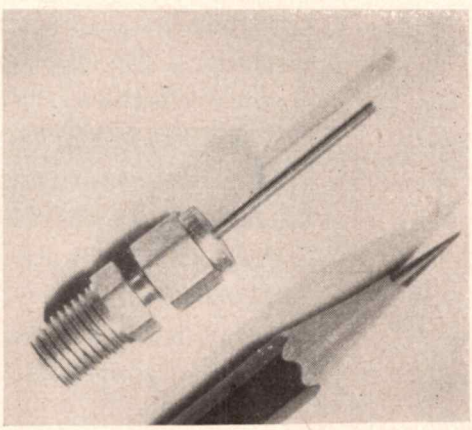
trol unit provides full stop, or full speed in the reverse direction, of the tape in five to six milli-seconds. The remote control feature permits control of tape direction, search, selective reading and writing, rewind, and stop. ElectroData Corp., 717 N. Lake Ave., Pasadena 6, Calif.



● Dual Range D.C. Power Supply

A power supply, for operating and testing electronic equipment in aircraft, that is said to have less than one percent alternating current ripple, provides a continuously variable source of voltages from 0 to 14 volts and 0 to 28 volts for loads of 0 to 5 amperes, and supplies intermittent loads up to 10 amperes. Current and voltages are indicated by D'Arsenval-type meters. Electro Products Laboratories, Inc., 4503 N. Ravenswood, Chicago 40, Ill.



● Capillary Tube Fitting

Because of difficulty in flaring small size tubing, fittings have not been available for capillary tubes in the sizes near 1/16 inch, since it is claimed to be practically impossible to get a satisfactory seal after small size tubing has been flared. Such a problem is said to be eliminated with the Crawford capillary Swagelok tube fitting that requires no flaring, no special tools for installation, nor any preparatory work on the tube. To install, the capillary tubing is slipped into the fitting, the nut turned until a tight seal is secured, and the installation is complete. Available in brass, aluminum, steel, stainless steel and Monel. The new fitting is in production and available from stock. Crawford Fitting Co., 884 E. 140 St., Cleveland 10, Ohio.

● Assembly of Hose for Jets

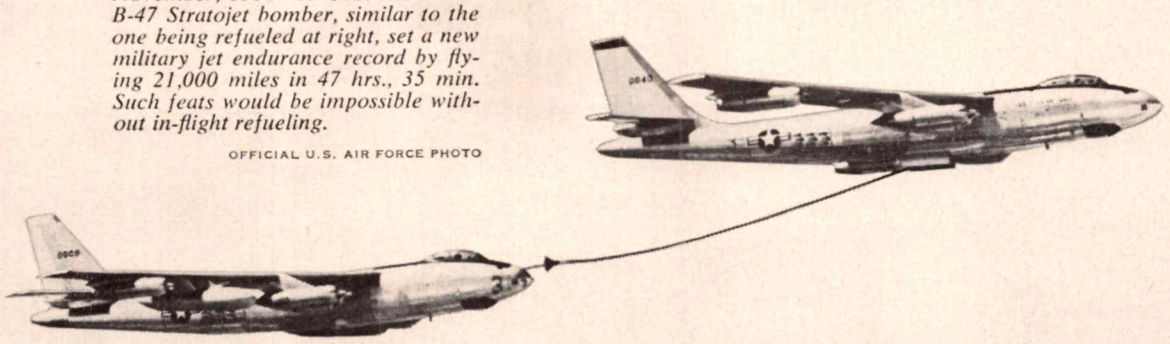
For field assembly of hose and fittings, a portable tool was developed for use with Resistoflex high temperature, corrosion-resistant hose. Known as *Fluoroflex-T R500*, the hose is used to handle the newer fuels and synthetic lubricants which are especially corrosive at the high operating temperatures of jet aircraft. Consisting of a crimping unit, hydraulic pump, and accessories, the tool apparatus fits into two carrying cases which can be handled and operated by one man. Since complete hose assemblies can be made on the spot and as needed, engineering of new installations is greatly facilitated, and stocking and maintenance problems simplified. The manufacturer claims complete hose assembly can be tailored on the job in as little as three minutes. Resistoflex Corp., Belleville, N. J.

● Sectional Terminal Block

The design of pres-SURE-block allows any number of circuit sections to be assembled into a 70 ampere 750 volt sectional terminal block. Three integrally molded serrated pins locate and secure each circuit section by mating with corresponding holes in the adjoining circuit section. This pin design permits limitless circuit sections to be assembled without the conventional sectional blocks having accessory fastening hardware or loose fitting sections. It is claimed this use of interlocking surfaces has also solved the flashover and leakage problem. Three contact types are available for stripped or terminal-ended wire from number 18 to number 4 wires. Contacts are electrolytically plated with copper and have positive wire stops. With maximum wire sizes installed in all contact types, contact screws do not project above block surface. Pres-SURE-blocks are interchangeable with conventional blocks of similar ratings,

November, 1954—A U.S. Air Force B-47 Stratojet bomber, similar to the one being refueled at right, set a new military jet endurance record by flying 21,000 miles in 47 hrs., 35 min. Such feats would be impossible without in-flight refueling.

OFFICIAL U.S. AIR FORCE PHOTO



26 YEARS OF PROGRESS ...in-flight refueling

OFFICIAL U.S. AIR FORCE PHOTO

January, 1929—The U.S. Army Air Force crew of the Fokker C-2 Army Transport "Question Mark" is shown after establishing a refueling endurance record covering 11,000 miles in 150 hrs., 40 min. Pictured, left to right, are Sgt. Roy Hooe, Lt. Elwood Quesada, Lt. Harry Halverson, Capt. Ira Eaker and Major Carl Spaatz.

In 1929, the historic flight of the "Question Mark" focused attention on air-to-air refueling. Recognizing the strategic importance of this concept, the U.S. Air Force has devoted an ever-increasing effort to the perfection of in-flight refueling.

At Fletcher Aviation, design and production engineers are currently working with the U.S.A.F. in the development of improved equipment to hasten this vital step toward maximum global mobility.

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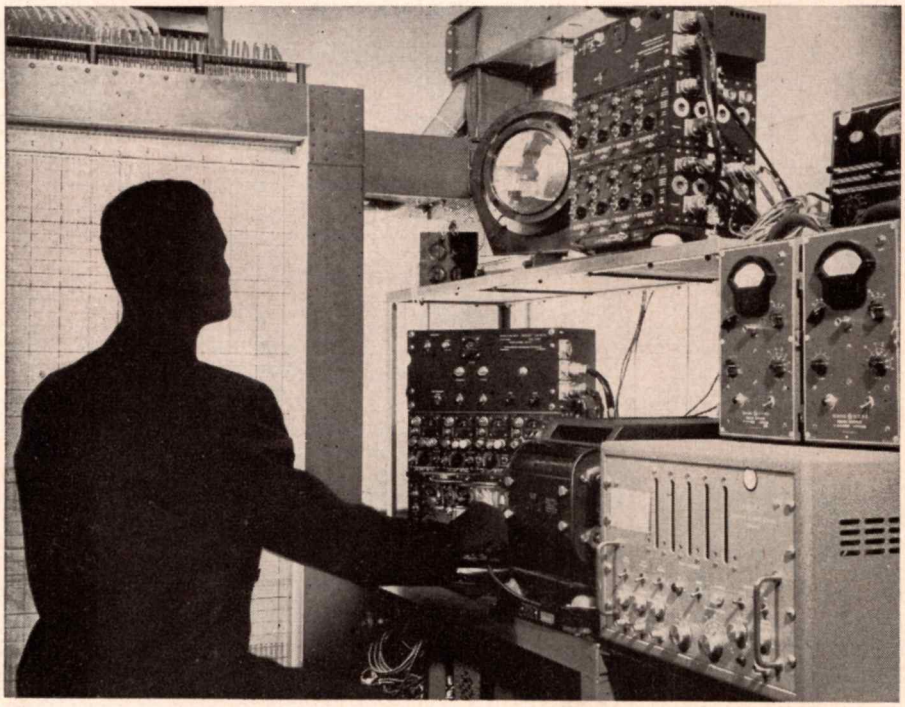
TO THE FINE ENGINEERING MIND
SEEKING THE CHALLENGING PROJECTS IN



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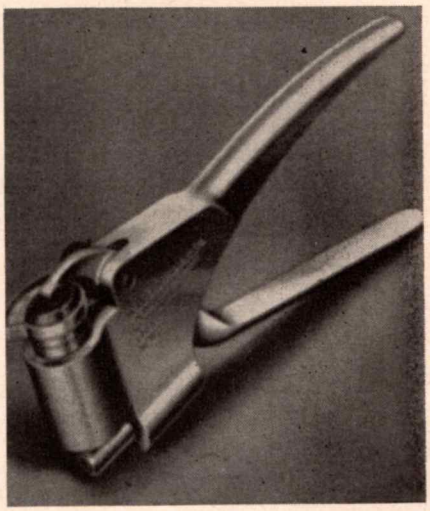
and are supplied in various MIL-P-14 molding materials. Buchanan Electrical Products Corp., Hillside, N. J.



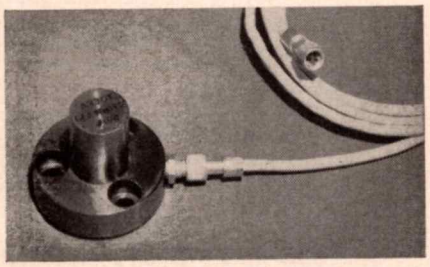
• Hardness Tester

The Webster Model BB-75 hardness tester tests soft materials, including electro-deposited copper, in the Rockwell E20 to E100 range. Other common materials, comparable in softness to fully annealed copper, can be tested. The tester features one-hand operation, a round anvil which permits testing of round, square, irregular and tubular shapes within its ¼ inch capacity. The test is made by placing the material being tested between the anvil and housing, and applying pressure to the handles until the housing contacts the material. Degree of hardness is read from the dial indicator. This reading can be correlated by means of a graph to a Rockwell E hardness scale. Webster Instruments, Inc., 11856 Mississippi Ave., Los Angeles 25, Calif.

• Self-Sealing Locknut

The new Type A2500 self-sealing anchor nut was made necessary by the trend toward the use of the *wet wing*, where the wing voids themselves act as fuel tanks, replacing individual bladder-type fuel cells. The nut is claimed to provide a positive seal against leakage pressures up to 50 pounds per square inch on either side of the sealing element, regardless of vibration, strain, or temperature changes. An all-metal self-locking nut body is enclosed by a one-piece aluminum cap with a sealing ring in the base, to prevent leakage under the base of the nut and past the bolt threads. The nut body is designed with a floating action of

0.025 inch in all directions, to provide ease of assembly and allow for misalignment of bolt holes. A full thread series is available, including 10-32, 1/4-28, 5/16-24, 3/8-24, and 7/16-20. These can be supplied in gang channel strips as well as individual nut plates. Elastic Stop Nut Corp. of Amer., Union, N. J.



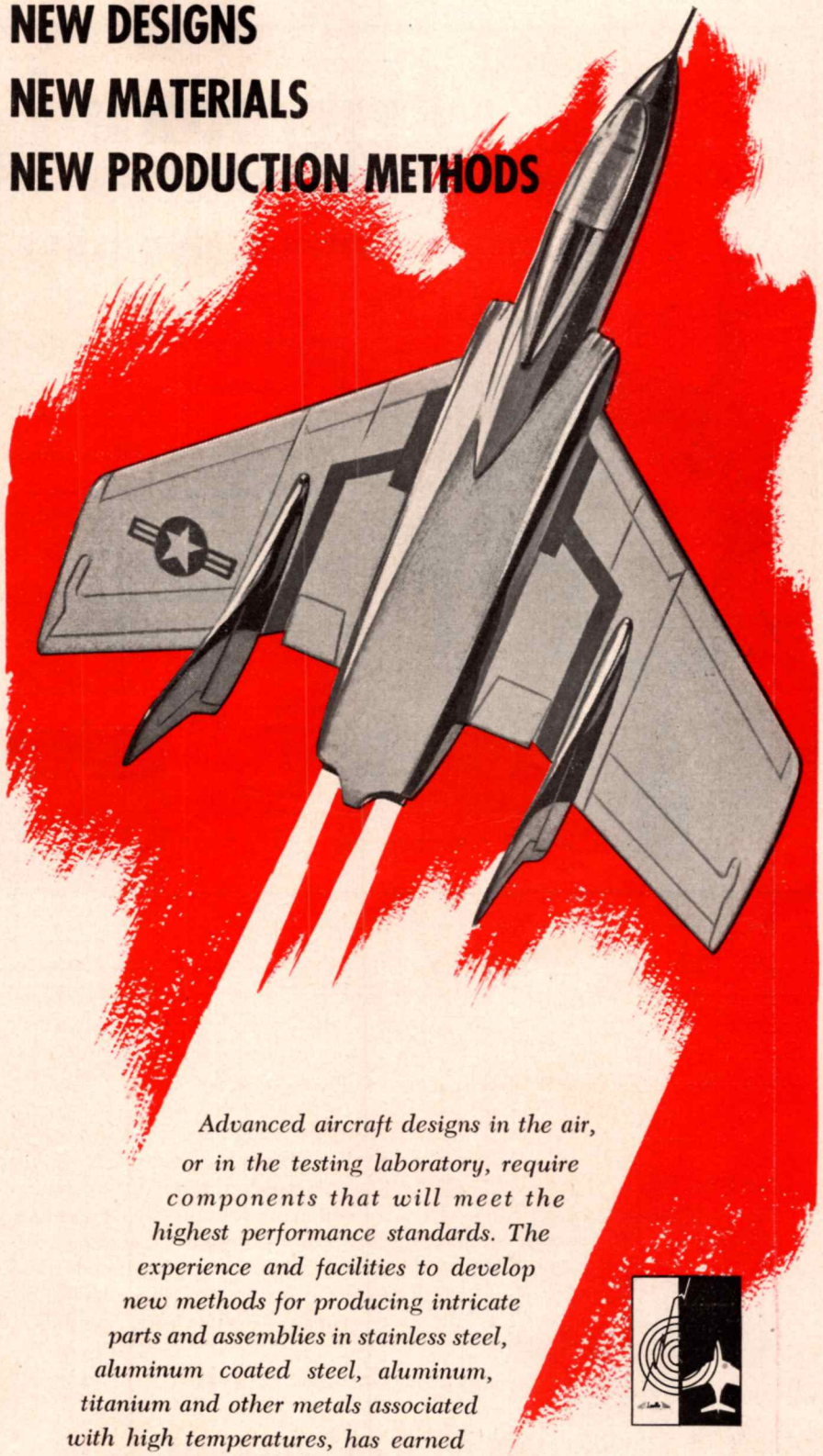
• High Range Accelerometer

Designed to withstand up to 30,000 g's without damage, a high range accelerometer is being produced for research in drop testing and impacts of projectiles against solid objects. Coupled with this feature is a claim of measurement accuracy of ±10 percent from 5 to 10,000 g's. The unit, designated Model A330, is designed to eliminate the effects of acoustic fields and blast pressures encountered with compression type accelerometers, and utilizing a special type piezoelectric ceramic, is said to provide better linearity and temperature stability than pure barium titanate. It measures 1¼ inches in diameter. Gulton Mfg. Corp., Metuchen, N. J.

• Semi-Expendable Dummies

Two new models, 157 and 160, were designed by Sierra Engineering to meet requirements for semi-expendable 100g dummies to be used in seat ejection tests, parachute drop tests, crash tests, and other human engineering tests. Model 157 features a large cavity in the torso, with mountings for a variety of test instruments, such as accelerometers, pressure pick-ups, rate gyros, tape recorders, batteries, or other instruments for sensing and recording. Mounting configurations are produced to customer specifications. They are built to the dimensions and weight distribution of a six-foot 200-pound man. Articulation of head, arms, thighs, legs, and feet, are provided. Standard helmets and oxygen

NEW DESIGNS
NEW MATERIALS
NEW PRODUCTION METHODS



Advanced aircraft designs in the air, or in the testing laboratory, require components that will meet the highest performance standards. The experience and facilities to develop new methods for producing intricate parts and assemblies in stainless steel, aluminum coated steel, aluminum, titanium and other metals associated with high temperatures, has earned for Lavelle the reputation for being foremost in precision fabrication for the aviation industry.

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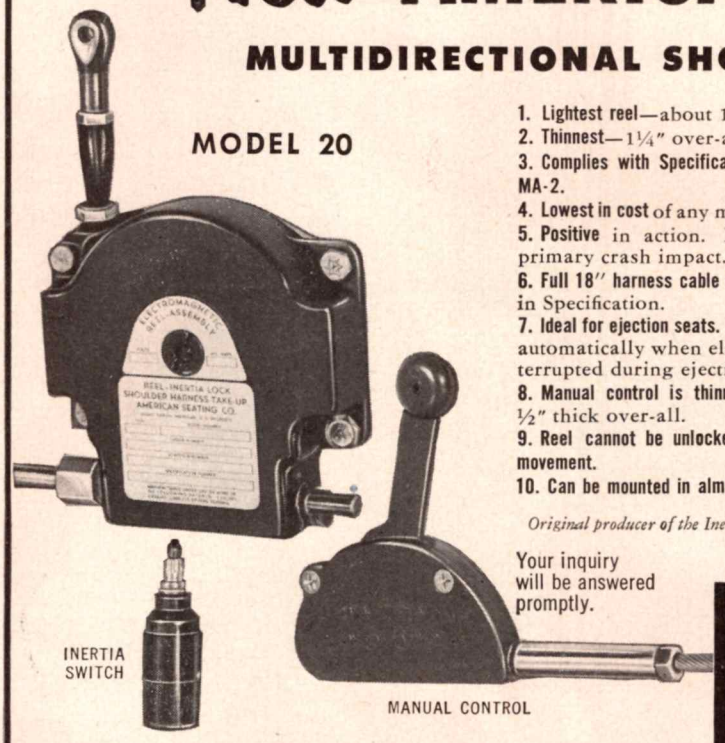
MULTIDIRECTIONAL SHOULDER HARNESS TAKE-UP

MODEL 20



1. **Lightest reel**—about 1.5 lbs.
2. **Thinnest**—1¼" over-all.
3. **Complies with Specification MIL-R-8236 Type MA-2.**
4. **Lowest in cost** of any multidirectional reel.
5. **Positive** in action. Locks instantly on primary crash impact.
6. **Full 18" harness cable travel,** as called for in Specification.
7. **Ideal for ejection seats.** Locks instantly and automatically when electrical circuit is interrupted during ejection cycle.
8. **Manual control is thinnest ever made,** only ½" thick over-all.
9. **Reel cannot be unlocked by quick retracting movement.**
10. **Can be mounted in almost any position,** as inertia locking action is controlled by a new inertia switch, mounted independently of reel. The light weight switch will operate several reels.
11. **Reel can be disassembled** and overhauled by user without returning to factory for recalibration. Only the trouble-free inertia switch is factory-sealed.
12. **Design incorporates suggestions** of aircraft manufacturers. Aircraft engineers available for consultation.
13. Uses same mounting hole spaces as other reels of our manufacture.
14. Mock-up units available for your development work.

We also make Unidirectional Reels conforming to Specifications MIL-R-8236 Type MA-1 and AN-R-29 amend 2.

Original producer of the Inertia Locking Shoulder Harness Safety Reel. Supplier to the Armed Forces since 1945. American Inertia Reels are fully protected by patents.

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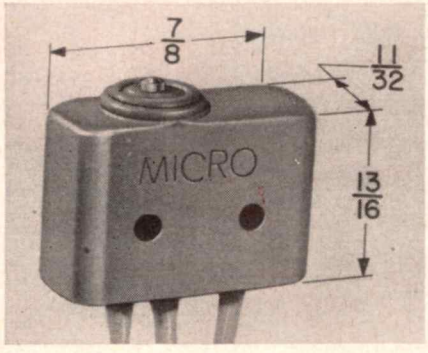
GRAND RAPIDS 2, MICHIGAN • WORLD'S LEADER IN PUBLIC SEATING

masks may be used. Instruction manual and complete parts list are included with each test dummy. Sierra Engineering Co., 123 E. Montecito Ave., Sierra Madre, Calif.

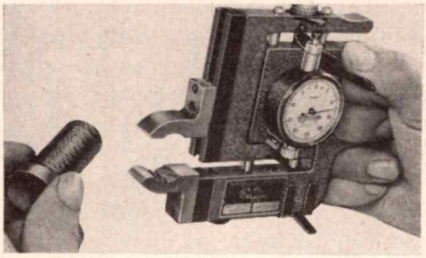


• Sealed Snap-Action Switch

Designed for aircraft applications where small size, lightwegiht and environment-proof construction are required, a new single-pole, double-throw switch, designated ISEI, operates in temperatures ranging from —65 degrees Fahrenheit to +180 degrees Fahrenheit. Complete sealing is accomplished with a silicone rubber plunger seal, bonded both to the pin plunger and the metal housing, and by embedment in an epoxy casting resin inside the housing. Exterior housing is of corrosion-resistant treated aluminum. Leads are available in lengths of 1, 3, 5, or 12 feet. Electrical ratings: 30 volts dc, 2.5 amperes inductive, 4 amperes resistive, maximum inrush 15 amperes. Operating force 5 to 17 ounces. Release force 4 ounces minimum. Differential travel 0.004 inch, maximum. Overtravel 0.003 inch, minimum. Micro Switch, Div. of Minneapolis-Honeywell Regulator Co., Freeport, Ill.

• Neoprene Protective Coating

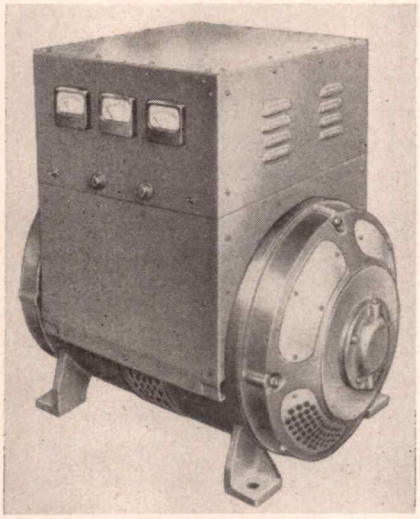
Neoprene W is a new one-component neoprene synthetic corrosion-resisting protective coating that is applied by brush or spray. Curing takes place at room temperature. It is recommended for maximum maintenance protection against most acid and alkali fumes and splash and high humidity. It is said to show excellent resistance to abrasion and weathering. No catalysts or accelerators are required. Drying time between coats is about two to three hours, and in most cases the coated surface can be placed in service after 24 hours. Coverage is 420 mil feet per gallon (140 square feet for a 0.003 inch film). According to the manufacturer, the bond of the repaired section is as strong as the original coating. Carboline Co., 331 Thornton, St. Louis 19, Mo.



• Multi-Purpose Dial Unit

The Versa-Dial gage is useful for checking internal and external threads, grooves, shallow counterbores, and narrow shoulders. Interchangeable segments for contacting

work surfaces are secured in T-slots at desired spacing. User may select segments from a variety of stock types, or in the case of unusual jobs have special ones made. Large dimensions can be checked through use of longer T-slots, or by trussed extensions. The gages may be equipped with indicators having either 0.001 inch, 0.0005 inch or 0.0001 inch graduations. To change the unit from external to internal use (or vice versa), it is necessary only to reverse the indicator, relocate a spring, and attach or detach the lifting lever. Standard Gage Co., Inc., Poughkeepsie, N. Y.



• Motor-Driven Generators

Palmer 400 cycle synchronous motor-driven generator sets are said to combine fast response time with minimum of dip and overshoot, and possess a maximum of stability. Voltage regulation of ±0.5 percent is provided from unity to 0.8 power factor. Response time is 0.015 to 0.150 seconds, depending upon power factor of the load. Units can be furnished with a total harmonic content as low as 0.25 percent. Palmer Electric Mfg. Co., Sub. of Leach Corp., 6629 Bear Ave., Bell, Calif.

• Quick Release Shear Pins

The only moving part of the Harley quick release shear pin, a locking pin, is activated by a silicone rubber core which is said to be impervious to temperatures ranging from —100 degrees to +500 degrees Fahrenheit, moisture, petroleum oils, alkalies and most acids. These pins are claimed

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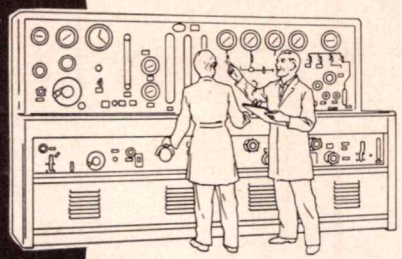
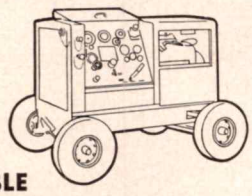
In addition to the machines shown here, SPRAGUE makes Fuel Flow and Fuel Pump Test Stands, Heating and Ventilating Test Units, High Pressure Hose Testers, Air Operated Hydraulic Boost Pumps, Filters, Cylinder type Accumulaters (3,000 and 6,000 psi.), Gage Protector Automatic Shut Off Valves and other equipment. Write for information.



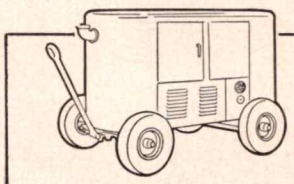
STATIONARY HYDRAULIC TEST STANDS

Tests aircraft hydraulic components, including engine driven pumps, at operating pressures up to 5000 psi. and with flows to 20 gpm. Provides multiple circuits to permit simultaneous testing of several units.



PORTABLE HYDRAULIC TEST STANDS

Standard units, 10 G.P.M. to 40 G.P.M. Motor or engine driven. For complete testing of aircraft hydraulic systems.



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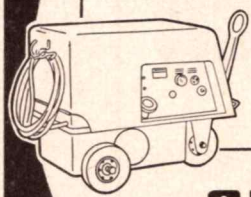
Supply clean, filtered air under controlled pressure to locate leaks and determine leakage rate.

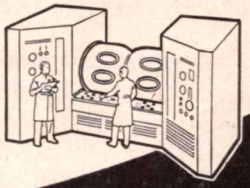
AIR OPERATED OIL DISPENSERS



Dispense clean, filtered oil simply, quickly, economically. One-man operation. Maximum safety.

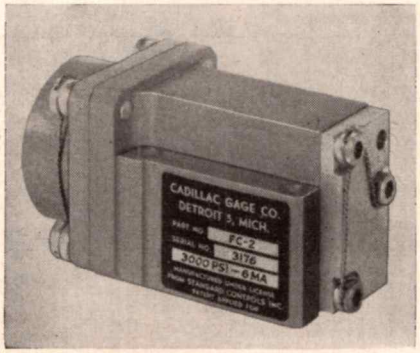
FUEL BOOST PUMP TEST STANDS

Designed especially to test submerged fuel boost pumps. Tests both A.C. and D.C. types.



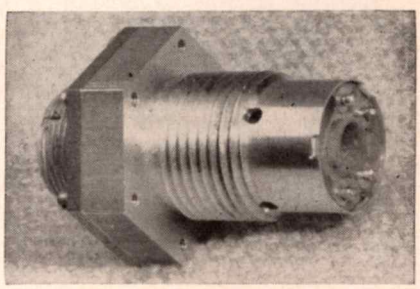
SPRAGUE Engineering Corporation
1144 W. 135th Street
Gardena, California

to be stronger than comparable hollow pins. The solid high tensile steel shank is said by the manufacturer to give full shear strength with a smaller diameter. The *release-pull* load can be regulated by cores of various hardnesses from 4 to 50 pounds, depending on pin size and requirement. Pins are supplied in varying lengths with diameters from ¼ inch and up, diameter increasing by 1/16-inch, and lengths by 1/10-inch increments. Harley Patents, 607 Fifth Ave., New York, N. Y.



● Flow Control Valve

The FC-2 is a two-stage, four-way flow control valve. Its pilot stage is a hydraulic amplifier of the nozzle type driven by a torque motor employing the polarized relay principle. A miniature, high force, positional feedback loop, between the torque motor and the main spool position, encloses the nozzle stage and gives excellent valve characteristics over wide ranges of supply pressures and ambient temperatures. The torque motor, of balanced coil resistance construction, is supplied in ranges of 200 to 3000 ohms direct current resistance per coil. Signal levels as low as a 6 milli-ampere differential current produces full valve flow when using the 3000 ohm coils. Supply pressures of from 500 to 3000 pounds per square inch may be employed, and a typical valve can deliver to the load a peak power of 10 horsepower. Cadillac Gage Co., Detroit 5, Mich.



● Liquid Level Switch

Rated by the manufacturer as ten times more sensitive to temperature change than any metallic conductor, a pinpoint-size resister is designed to solve the problem of fuel management and center-of-gravity control. This negative-temperature coefficient resistor is the detecting element in a new liquid level switch now being volume-produced. The switch is used to sequence the flow of fuel from tanks to maintain constant center of gravity in high-thrust jet types of missiles, to automatically close refueling valves in bombers, and to provide low-level fuel warning in aircraft. Use of the fuel-detecting elements helps solve the problem of maintaining a missile on course despite its constantly changing fuel load and increasing Mach Number. This is accomplished by mounting the thermistor in fuel tanks or fuel lines where it detects the presence or absence of the liquid according to mi-

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fabricators for the aircraft industry
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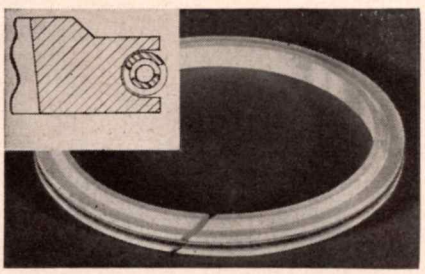
FARMINGDALE, NEW YORK

nute temperature changes. By detecting and utilizing differences in resistance, it is possible to indicate when the thermistor changes from one environment to another. Thermistors are available in various resistance values, and in bead, disc, washer, rod, flake and printed patterns, making it possible to design sensing equipment for a variety of other aircraft applications. Aeronautical Div., Minneapolis-Honeywell Regulator Co., 2600 Ridgeway Rd., Minneapolis 13, Minn.

• Integrating Gyro

A new Hermetically-Sealed Integrating Gyro is stated by the manufacturer to radically reduce space and weight requirements for fire-control and missile applications. The unit is one inch in diameter and slightly over two inches long. Preproduction quantities of this HIG-3 gyro are available. Greenleaf Manufacturing Co., 7814 Maplewood Industrial Court, St. Louis, Missouri.



• Low Friction Scraper Ring

The Shamban S-11065 hydraulic piston rod scraper ring for aircraft and industrial use is made to aircraft tolerances from low-friction, nonscoring, tough and inert Teflon or Nylon. Use is claimed to insure seal reliability, and to extend packing life by keeping dirt and other foreign matter away from vital O-ring seals. Compared to rings of conventional material, Shamban rings are stated to be responsive to rod misalignments, have less friction, and not to score the rod. It is for use in aircraft and hydraulic cylinders, shock struts, hydraulic actuators, control valves and pneumatic equipment. Operating temperatures range from —100 degrees to +300 degrees Fahrenheit. The ring is spring loaded to maintain firm contact on the rod. S-11065 ring dash numbers correspond to dash numbers of AN6231. W. S. Shamban & Co., 11617 Jefferson Blvd., Culver City, Calif.

CANNON battery PLUGS & receptacles

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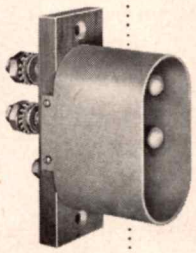
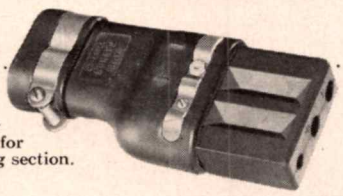
2551—Rubber shell held together with strap clamps. Two 7/16" socket contacts for power connection. Rating 400 amp. One 5/16" socket contact for relay and/or indicator light on instrument panel. This plug (without cable) offers you greater flexibility than similar plugs with integral molded cable.

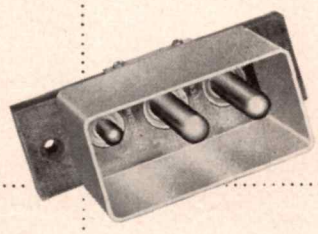


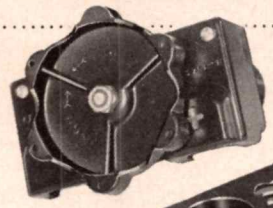
AN2552—Mates with AN2551. Linen bakelite or melamine bonded glass mat-laminated insulation. Available with or without shield.



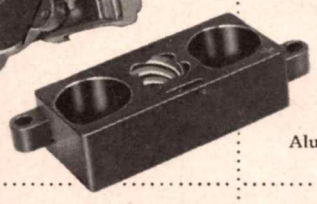
MS25019—Similar to AN2551 except for rectangular mating section. BuAer approved.

MS25018—Mates with MS25019. BuAer approved. Features rectangular shield. Two 7/16" and one 5/16" pin contacts. Insulated with strong melamine bonded glass, mat-laminated.

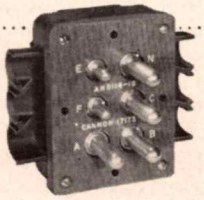




11751-1—Small in size. Light in weight. Used for batteries built to AN-W-B-141 specifications. Easy to connect, using center wheel and gear. Eliminates spark hazards from terminals striking any part of the ship during installation. Two socket contacts for B&S No. 00 wire connection. Rating 600 amp. Shell of molded phenolic. Handwheel die-cast aluminum.



11749-1—Mates with 11751-1. Offers full protection against hazardous accidental spark. Aluminum alloy housing.



AN3114—External power receptacle. Tellurium copper contacts, silver-plated. Insulated thermosetting glass cloth laminated with melamine resin. With or without synthetic rubber cover.

Need battery connectors?

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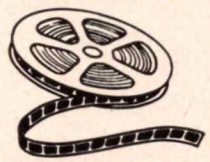

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UNDERCOVER

1954 AIRCRAFT YEAR BOOK, 36th Annual Edition, official publication of Aircraft Industries Association, Inc. 1955, Lincoln Press, Inc., Washington, D. C. 480 pp., $6.

The Year Book, a standard reference volume of the aviation industry, features a complete rundown, within the limits of security, on the latest in Guided Missiles. As in previous years, the book also includes Military Aviation, significant tactical and strategic developments in all branches of military aviation during 1954; Utility Planes and Helicopters, including latest design improvements, industrial uses, general market trends and sales; Planes in Production, detailed description of all U. S. civil and military aircraft in production in 1954, with specifications, performance data, three-view drawings, and photos; Engines in Production, specifications and performance figures, accessory items, and installation data on all U. S. engines, reciprocating, turbo and jet; plus: Official Aviation Records; Day-by-Day Chronology; Historical Chronology; Biographical Briefs; Government and Aviation; Airlines; and Bibliography, a complete listing of aviation books published in the U. S. during 1954.

DEVELOPMENT OF THE GUIDED MISSILE, Second Edition, by Kenneth W. Gatland. 1954, Philosophical Library, New York, 292 pp., $4.75.

The new edition has been completely revised and enlarged. New chapters deal with problems of propulsion, research into rocket techniques and requirements, and post-war work on guided bombs. Of particular interest is the survey of Soviet potentialities for long range rocket development.

MASSBALANCING OF AIRCRAFT CONTROL SURFACES by H. Templeton. Volume IV of *Aeronautical Monographs* Series. 1954, Chapman & Hall, Ltd., London. 241 pp., 35s.

The monograph is concerned with the application of massbalancing to the prevention of flutter of aircraft control surfaces. Two main objec-

tives have been pursued: to provide an understanding of the basic principles underlying the application, and to give a factual account of the historical development and present day application of the massbalance principle. Some discussion has been given on possible future developments.

AN INTRODUCTION TO RELAXATION METHODS by F. S. Shaw. 1953, Dover Publications, Inc. 396 pp., $5.50.

The author undertakes to show, by relaxation methods, how to solve linear simultaneous algebraic equations, linear ordinary differential equations, linear partial differential equations, differential equations, integral equations, free surface equations, and eigenvalue problems involving algebraic, ordinary differential and partial differential equations.

VIBRATION PROBLEMS IN ENGINEERING, Third Edition, by S. Timoshenko. 1955, Van Nostrand Co., New York. 468 pp., $8.75.

This new edition of a standard text has been revised to incorporate some of the more important new developments in the vibration field. The first chapter, dealing with systems having one degree of freedom, has been re-done in order to cover a wider range of applications. The second chapter, dealing with nonlinear vibrations, has been expanded and some new methods of treating such problems have been presented. To simplify the book for those having had only elementary courses in dynamics, the use of Lagrangian equations has been dropped in favor of the familiar d'Alembert's principle. Aside from this change, those chapters dealing with systems having several degrees of freedom have not been greatly altered. The fifth chapter on vibrations of elastic bodies has been completely revised and several new topics, such as coupled bending and torsional vibrations of beams, are discussed.

THE GYROSCOPE APPLIED by K. I. T. Richardson. 1954, Philosophical Library. 384 pp., $15.

The material covered includes the fundamental theory of the gyroscope, its marine applications, aeronautical applications (navigational instruments, gyro-verticals, rate of turn indicators, automatic pilots, flight director), military applications (weapon sighting, control of missiles), and other applications including possible future ones.

AIR NAVIGATION, Fourth Edition, by P. V. H. Weems. 1955, Weems System of Navigation, Annapolis, Maryland. 473 pp., $6.

The volume covers a large number of aspects of air navigation: basic fundamentals such as charts, magnetism, pilotage and dead reckoning through omni-range, loran and radar to pressure pattern flying, celestial and polar navigation as well as flight planning. A feature is the chapter "The Navigator at Work." The author describes in detail all procedures, both operational and navigational, taken by a pilot of a four-engine transport plane from the time that he is scheduled to depart from San Francisco on a trans-Pacific flight until he lands at Honolulu Airport. The track and navigation work of this flight are plotted on a Pacific navigation chart reproduced on the four end-pages. END

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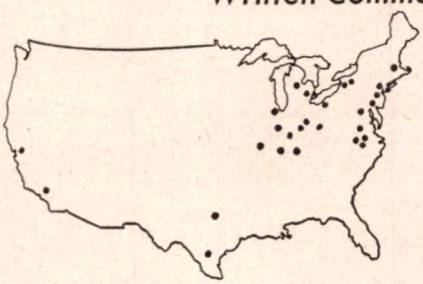

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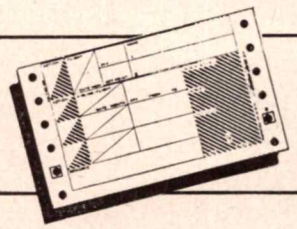

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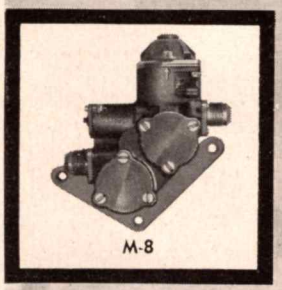
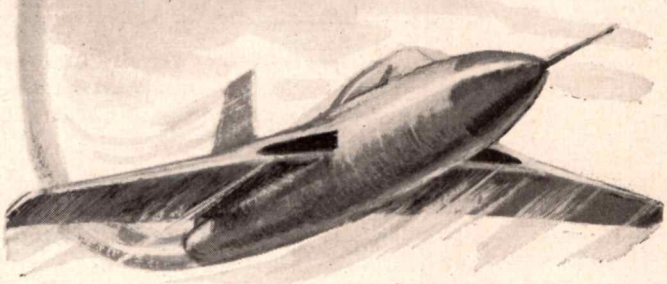
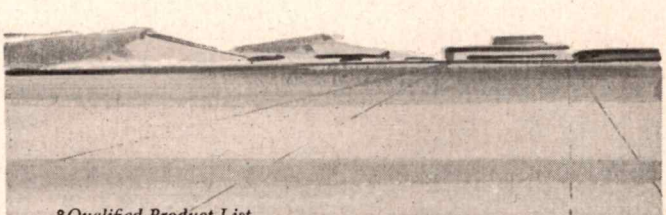
The same valve mechanism is also available in the Type MD-1 which incorporates swivel fittings for difficult mounting locations. Engineering data on this and/or a list of other Gladden products available on request. Write us today.



M-8





*Qualified Product List

Gladden

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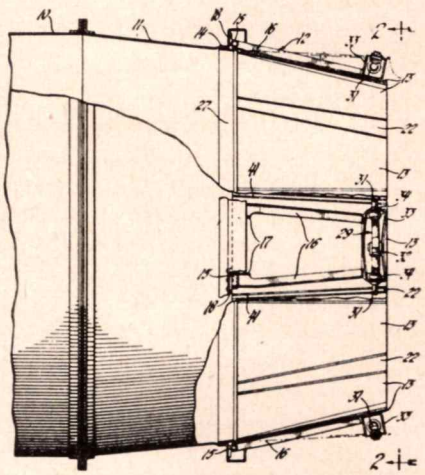
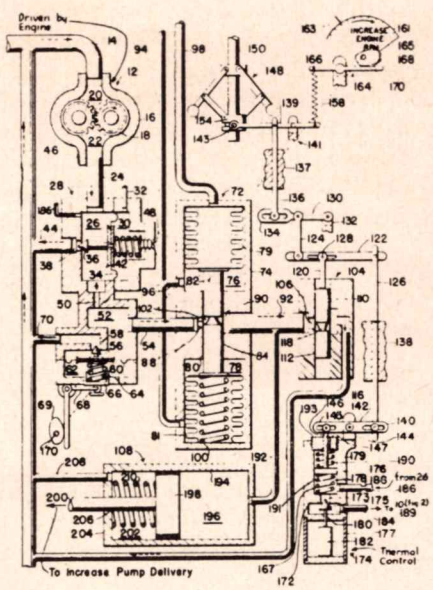
THE TREND OF INVENTION

Multiplate variable area jet nozzle (2,697,907). A. W. Gaubatz, Indianapolis, Ind., assignor to General Motors Corp.



A group of main segments tapered toward their free ends, and inverted channel-shaped ring member secured to a fixed nozzle section, and hinge connections to permit adjustment of the segments to vary the area of the jet nozzle.

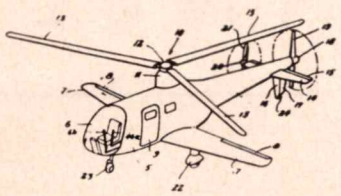
Fuel control for turbojet engines (2,697,909). M. E. Chandler, New Britain, Conn., assignor to Niles-Bement-Pond Co.



Means for regulating the flow of fuel from a fuel source at super-atmospheric pressure responsive to an air pressure differential.

Fluid fuel burner with self-contained fuel vaporizing unit (2,697,910). W. Brzozowski, Newtonville, Mass., assignor to Thermal Research and Engineering Corp.
A tube through which high velocity air moves, a gourd-like chamber within the tube, having an open-ended extension projecting downstream through which the fuel in the chamber is vaporized.

Aircraft with fixed wings and lifting rotor (2,698,147). P. E. Hovgard, Hagerstown, Md.

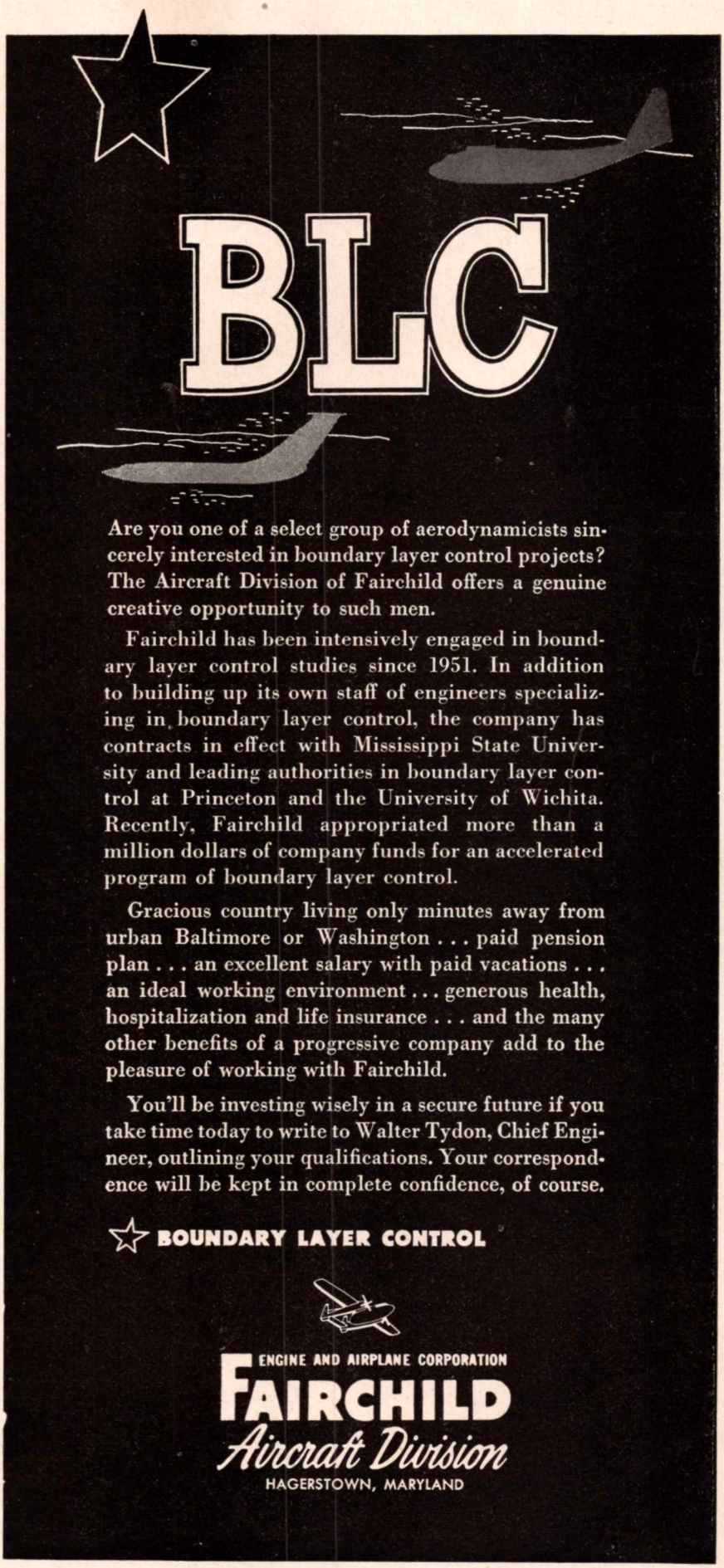


Rotor blades arranged for pitch change, and a fixed wing capable of supporting the aircraft at high speeds, a directional propeller with controllable-pitch blades, and a drive system between the engine and the rotor.

Aircraft speed retarding device (2,698,149). E. J. Greenwood, Stratford, Conn., R. I. Sears, Hampton, Va., and P. S Thorjusen, Dallas, Tex., assignors to U. S. Navy.
An air brake comprising a panel hinged to the fuselage at its forward edge and arranged to swing into the airstream when the aircraft is in flight, and a flap hinged to the rear edge of the panel to reduce wind loads on the panel.

Control for stallproof and spinproof three-control airplanes (2,697,567). H. Fiedler, Chicago, Ill., assignor to Goodyear Aircraft Corp.

ACKNOWLEDGMENTS (Left to right, top to bottom) p. 5—Republic Aviation Corp. 7—Northrop Aircraft Inc. 12 — Trans-Canada Air Lines. 26—DuMont 38—A. V. Roe, Canada, Ltd. 52-56 — Beech Aircraft Corp. 58-60—General Electric Company. 62 — Convair — A Division of General Dynamics Corp. 68-72—Curtiss-Wright Corp. 74—Goodyear Tire and Rubber Company. 90-91—Lockheed Aircraft Corp. 94-96 — Martin Aircraft.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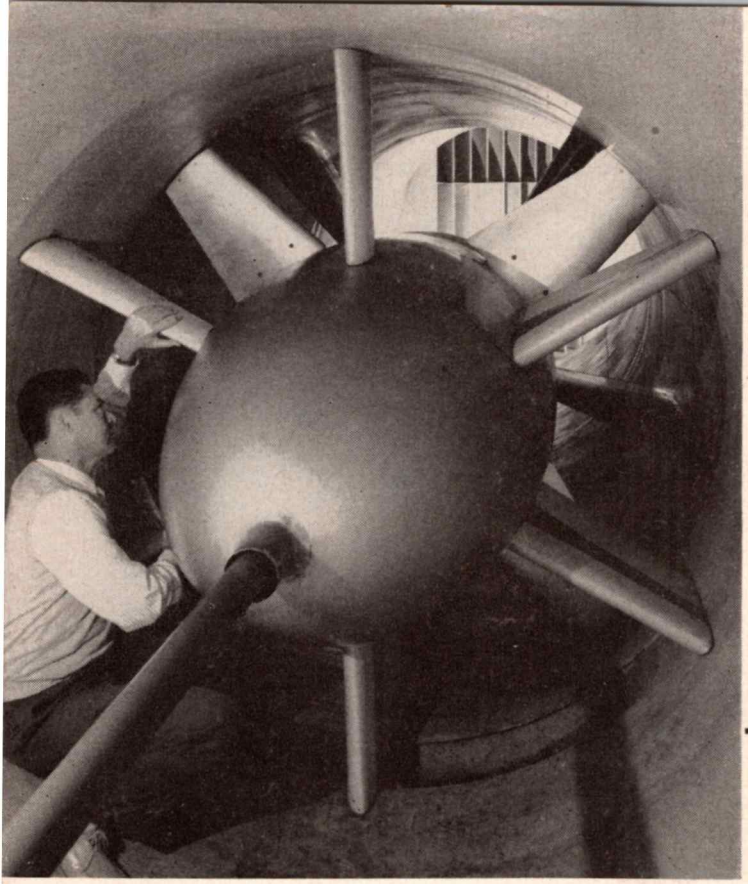
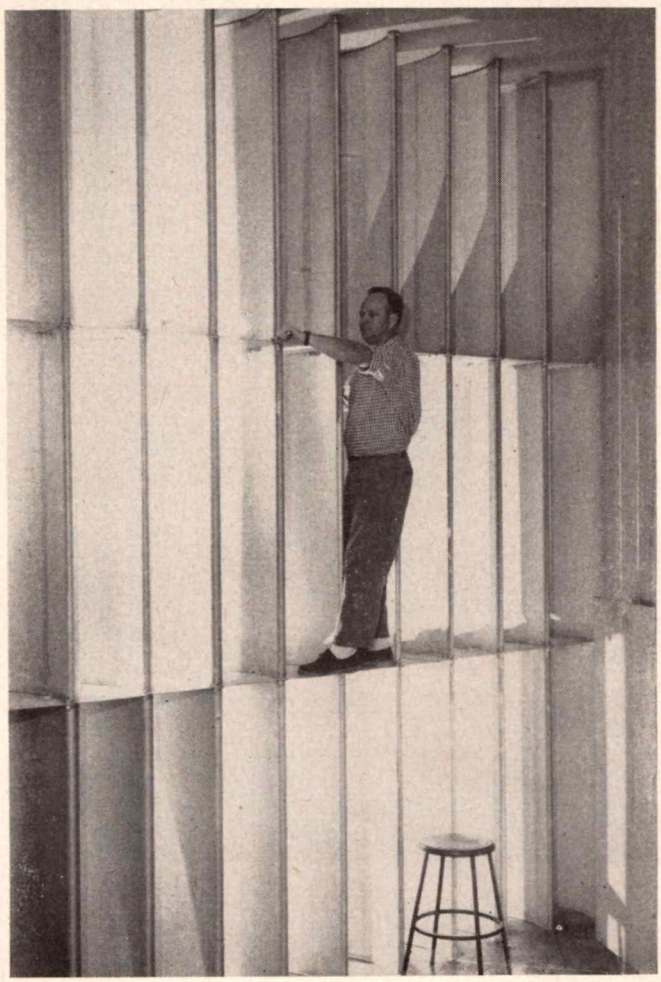


Seven foot diameter fan drives air through 204 foot long tunnel. Fan is turned by 15-foot long shaft whose drive motor is outside the tunnel. In the rear are vertical vanes that turn the air stream around one of the four corners.

In-Flight Icing Conditions Studied in BLIZZARD TUNNEL

Every attachment bolt in the turning vanes is tightened after a full scale run. Flush overhead lights are installed in the tunnel, although in the photograph sunlight coming through an open door is providing illumination.



In a working section two-and-a-half feet by four feet, Lockheed's newest wind tunnel can sustain temperatures —40 degrees to 150 degrees Fahrenheit, and wind speeds ranging from 15 to 270 miles per hour.

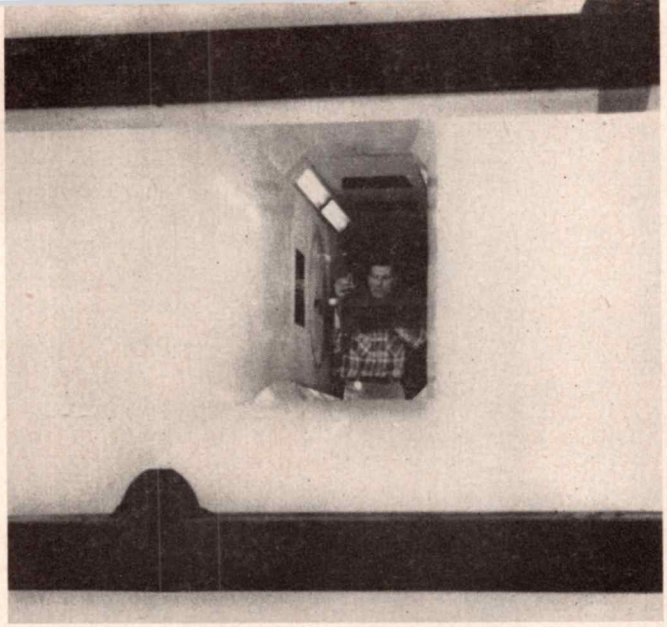
The tunnel, said to have cost $160,000, is being used to furnish data about the pattern and rate of ice formation with the end view of eliminating in-flight icing conditions. By adjusting the amount of air flow in the tunnel, and the temperature and amount of water sprayed into the air stream, the engineers are able to simulate high-altitude weather conditions.

Upstream from the working section, nine spraying units introduce water into low temperature air. The air is cooled at a fifteen foot by nine foot section of the tunnel refrigerated by a plant containing three 34-ton compressors; system has a capacity of 1.2-million btu/hr.

A seven foot diameter fan, powered by a 200 horsepower, 1200 rpm induction motor, drives the air through the tunnel whose overall dimensions are: length, 76 feet; width, 26 feet; height, 17 feet.

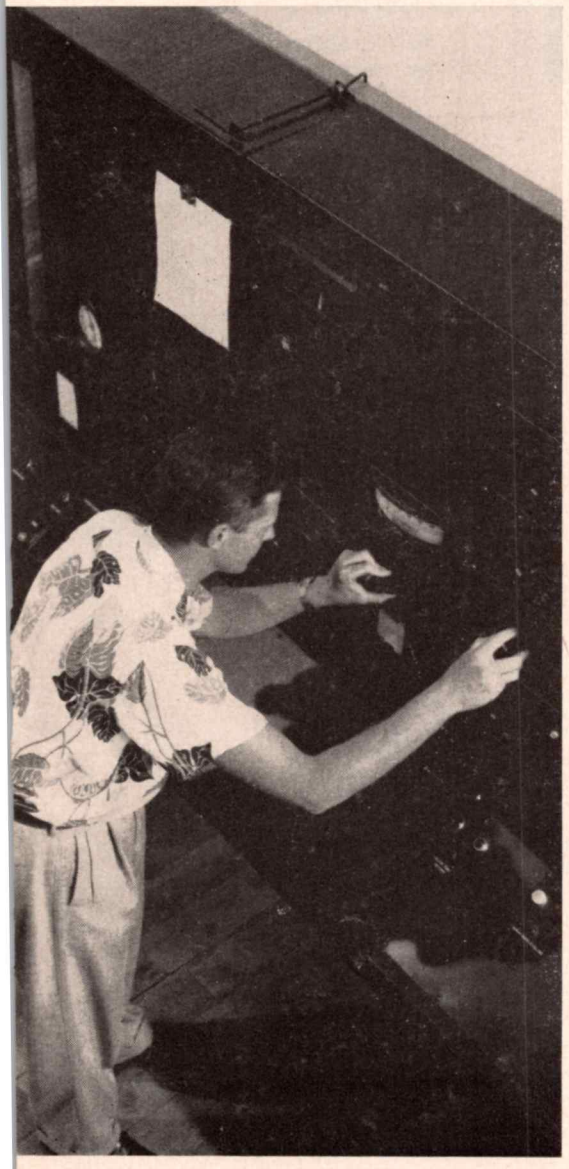
Work began on the new tunnel slightly more than a year ago, following two years of study and design.

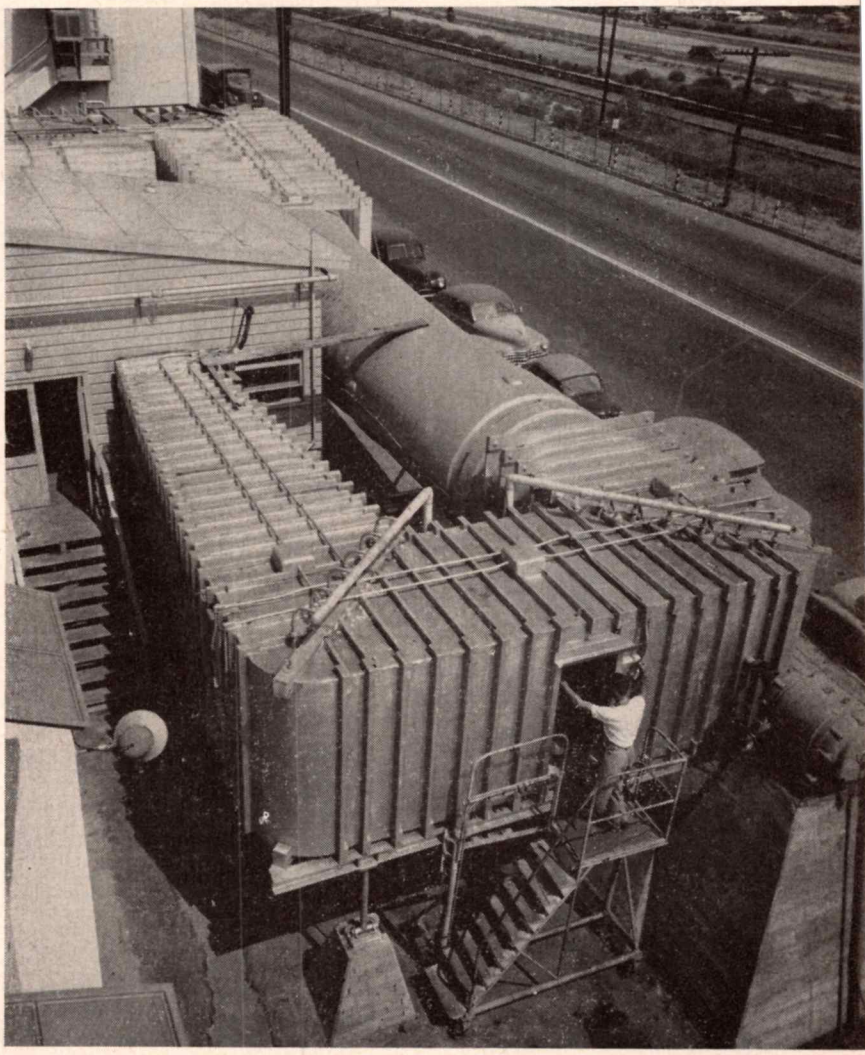
Engineer measures ice accumulation on a wing section from Lockheed's new C-130 turboprop transport, which is being used here to determine ice patterns before the wing's de-icing system is turned on.



Technician stands in trapdoor and makes adjustments in working section of tunnel. The odd bulges on the bars in the foreground emit water spray into the refrigerated air. Water entering the sprayer must be heated to 150 degrees Fahrenheit to prevent its freezing in its pipes.

Technician manipulates control-board dials to get correct airspeed in tunnel, and right water temperature. As photograph was taken, tunnel temperature was passing through 20 degrees Fahrenheit and falling fast.





Exterior view of Lockheed's new blizzard tunnel. Building at left, covering part of tunnel, houses test section and instrument panels. At bottom right, mounted on a concrete stand, is the motor that drives the seven foot fan. At the far end of the building are the refrigerating units and access doors.

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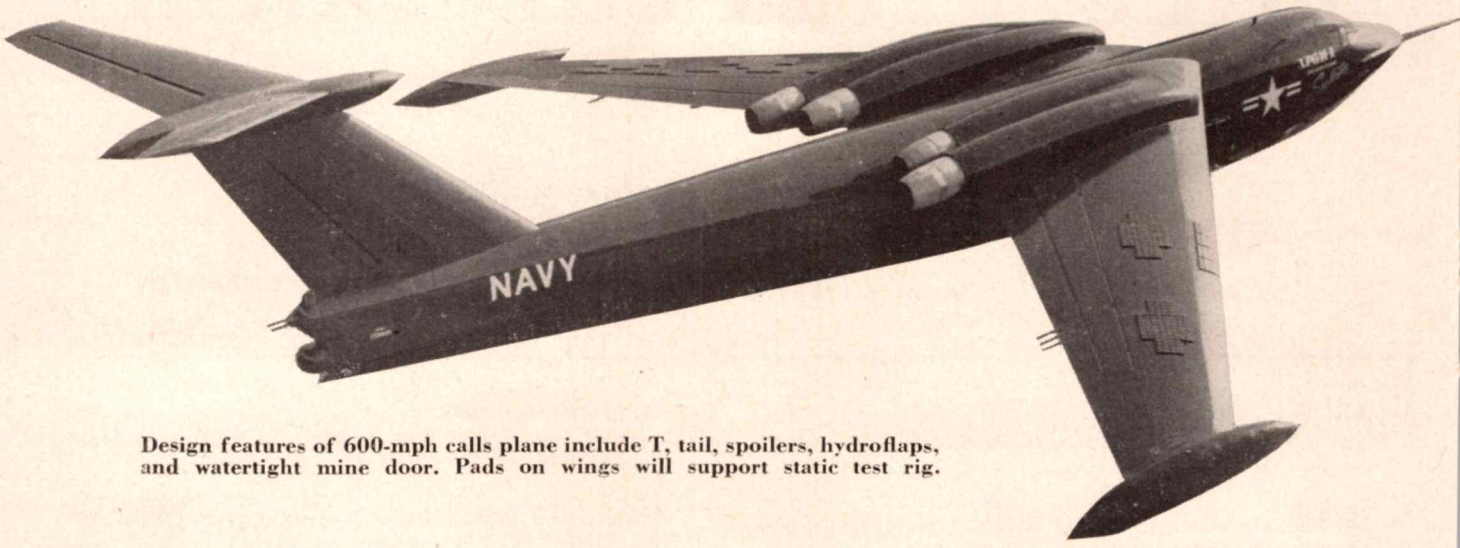
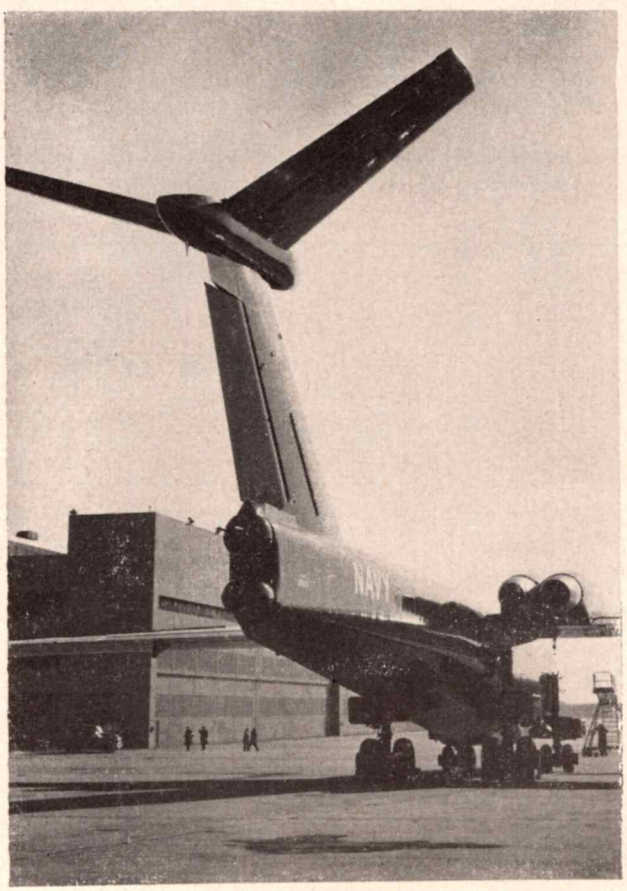


Design features of 600-mph calls plane include T, tail, spoilers, hydroflaps, and watertight mine door. Pads on wings will support static test rig.



T-tail design reduces structural weight and drag, and elevates control surfaces to top of plane's fin where possibility of spray damage is eliminated. Long slender hull reduces drag to allow speeds over 600 mph.

POWERED by four Allison J-71 turbojet engines with take-off afterburners, the XP6M-1 *SeaMaster* built by Martin Aircraft for the Navy is expected to be in the air early this spring. Its primary missions are minelaying and photo-reconnaissance.

Performance

The *SeaMaster* is said to be in the same performance class as landplanes, and to be the first seaplane in the 600-mph bracket. Its long 15-to-1 beam-to-length hull, low chine bow, and faired step could give the ship the minimum drag characteristics of a land-based medium bomber.

It is reported that in calm sea the seaplane's take-off time would be 45 seconds, take-off distance, one mile.

The plane has been designed to cruise normally at 40,000 feet. In flight, the cabin can be pressurized to 21,000 feet against a true altitude of 50,000 feet.

The *SeaMaster* contains in its hull a watertight rotary mine door in which mine stores or a camera pod can be installed. A 30,000-pound stores load can be carried.

Specifications

The following dimensions are approximate: height (from bottom of hull to top of empennage), 32 feet; wing span, 100 feet; fuselage length, 120 feet; wing cathedral, three degrees.

Lateral control is effected by plate-like spoilers, in two structural sections on each side of wing, that de-

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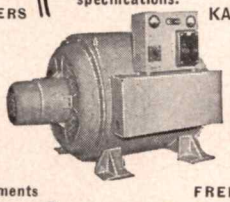

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flect upwards only; maximum deflection is about 45 degrees.

Structural design of seaplane has been based in part on "Maximum Sea State" Number 3, which is a *Moderate Sea;* this state is between *Slight Sea* and *Rough Sea.* Number 3 has average wave heights varying between three and five feet.

In normal sea and with normal gross weight, both wing tip floats are in the water at the same time.

The turbojet engines are installed in two pairs of engine nacelles on top of the wing, one pair on each side of the fuselage. This location gets the engines out of the spray and makes servicing of them and replacement relatively simple.

The *SeaMaster* carries a crew of five, including pilot, co-pilot, navigator-minelayer, radio operator, and armament defense operator. Interior arrangement includes a bow radome enclosing a radar scanner; main deck with pilot compartment; entrance compartment where anchor and anchor gear are stowed; flight deck compartment for crew members; and a pressure lock for in-flight access to unpressurized areas.

The electrical and electronics compartment is beneath the flight deck. To the rear of the pressurized area is the mine bay compartment. This compartment includes a portion of the main wing in the upper section, fuel tanks, air conditioning and anti-icing equipment, and tracks with a small trolley on which crewmen manually pull themselves forward or aft above the stores of mines or other equipment below.

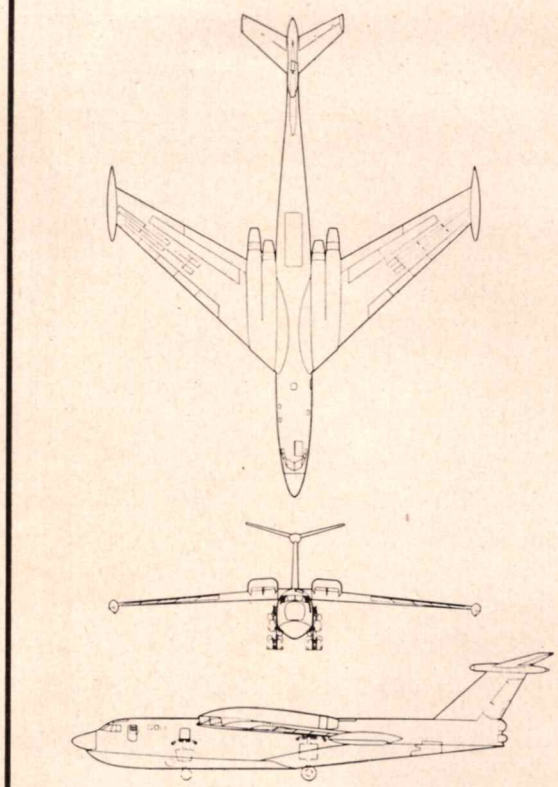
Aft of the mine bay is the mine-loading compartment which extends the full height of the plane's hull. Mines or other stores are loaded into this compartment through a large hatch in the top of the hull. Rear compartments house electronic equipment for the tail turret and the auxiliary power plant.

● ● Design Features

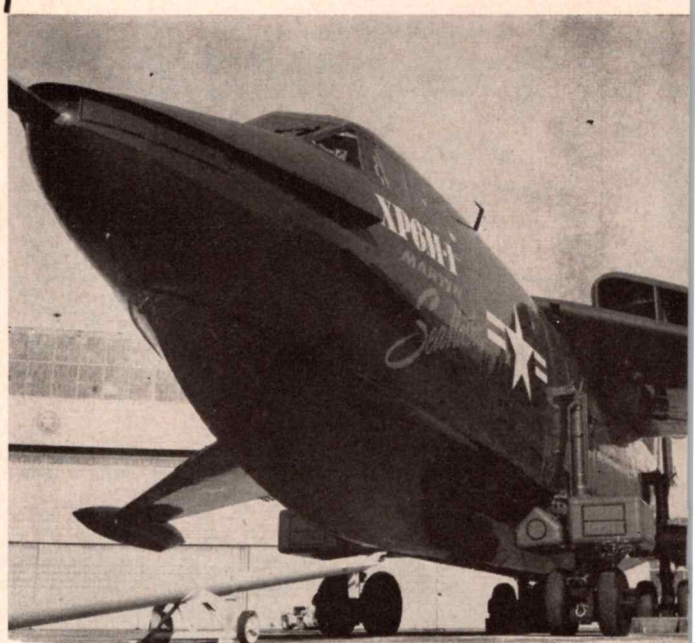
The characteristic Martin "T" tail provides endplating for the vertical stabilizer thereby increasing its efficiency; also in this way the horizontal stabilizer is kept out of the jet stream and wing downwash.

Hydroflaps are installed on each side of the hull afterbody. Opened together, these flaps act as brakes; opened separately, they serve as rudders that enable the ship to make small radius turns.

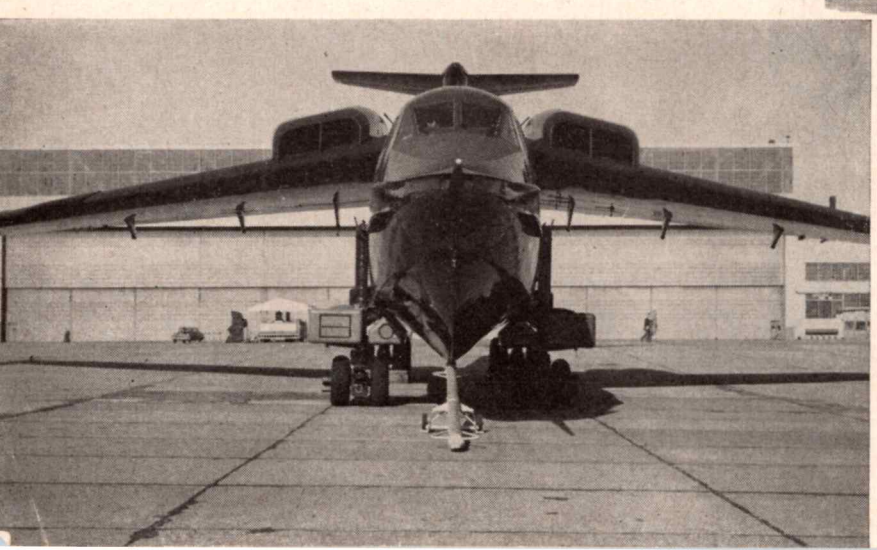
Upper portions of the *SeaMaster's* engine nacelles contain hinged panels extending full length and width of the engines to permit engine changes while plane is afloat. END



Three views of *Seamaster*. Approximate dimensions: height (from bottom of hull to top of empennage), 32 feet; wing span, 100 feet fuselage, 120 feet; wing cathedral, 3 degrees.



New attack seaplane features 15 to 1 streamlined hull, and two pairs of jet engine nacelles on top of wings.



Front view of *Seamaster*.

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• Science of Geartronics

A brochure issued by Technical Products Co. describes the new science of "Geartronics." Electronics engineers and those concerned with the application of atomic energy to industry will find this treatment revealing as it touches upon the use of precision gears used under conditions of exceedingly high speeds or extreme temperatures. One of the problems solved by the application of this science includes the development of a gear train capable of a speed of 104,000 rpm; another problem was the design of a complicated precision gearing, operative with peak efficiency at high speed, under Arctic cold conditions. Technical Products Co., Inc., West Concord, Mass.

• Extreme Pressure Lubricant

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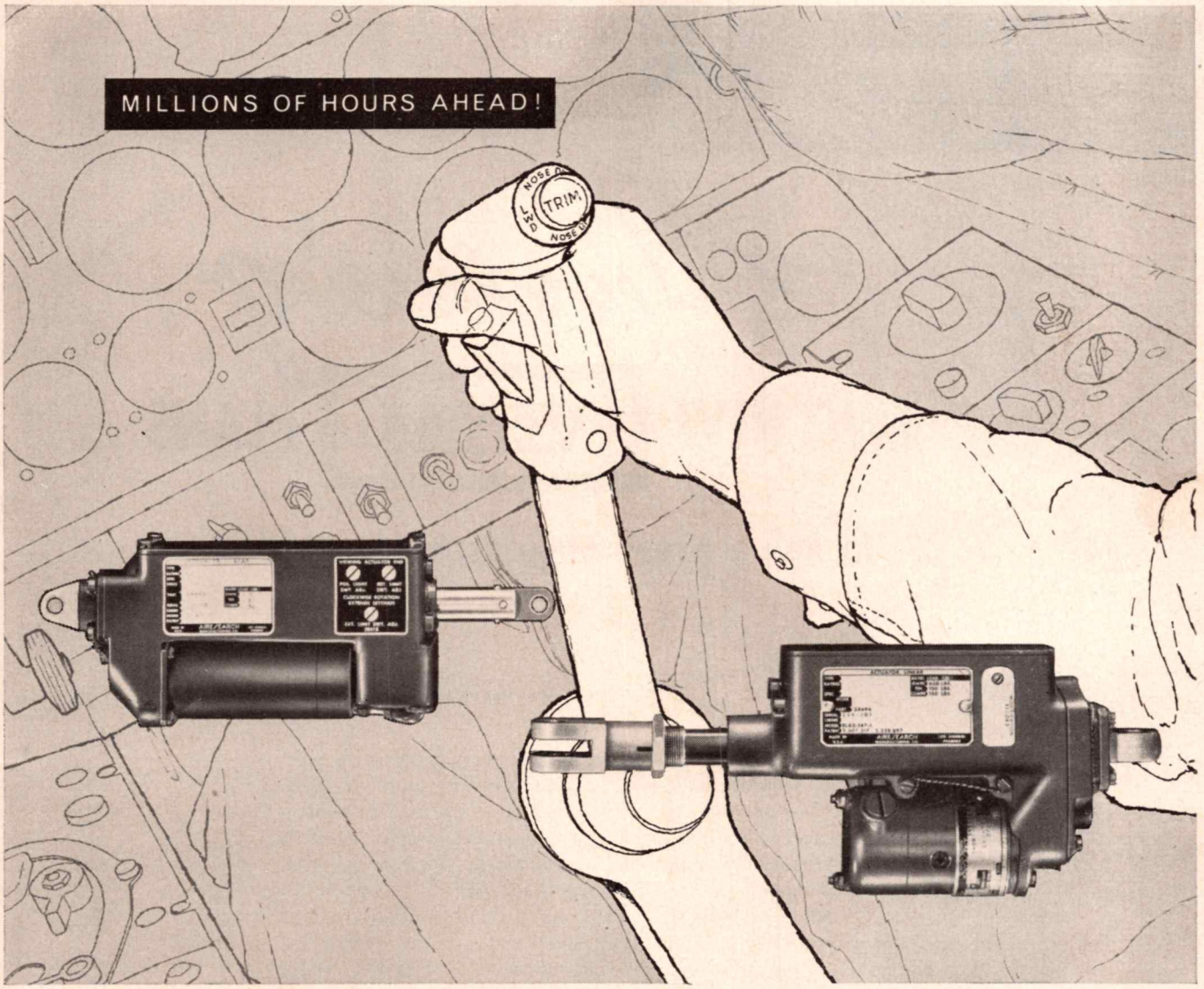

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